THE NEW IRRIGATION ERA

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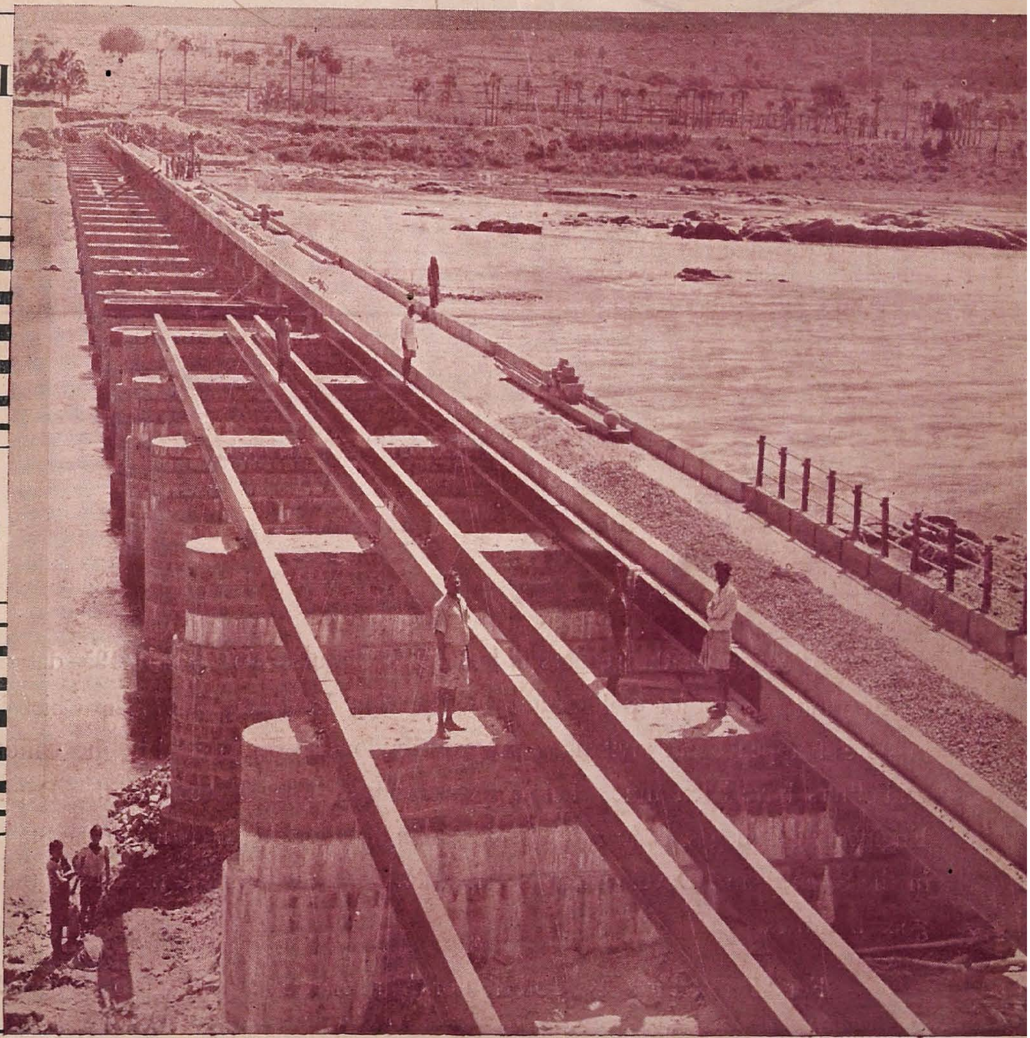

FOR DEPARTMENTAL CIRCULATION ONLY.

OUR FRONT COVER

METTUR CANALS SCHEME

Cauvery Pressure Aqueduct

The scheme consists of excavating a canal starting from the High Level Supply Channel of the Mettur Dam running along the foot of the Palamalai hills on the right side of the Cauvery, for irrigating the strip of land between the canal and the Cauvery river. At its 4th mile is the off-take of the Left Bank canal. This crosses the Cauvery river by a Pressure Aqueduct. The aqueduct consists of Twin steel pipes 6'-6" diameter carried over piers across the river, connected to the canal headsluice by R. C. Twin Box structure each conduit being 7'-6" x 7'-0". The connections with the earth channels on the left of the Cauvery is similar.

The following are the salient features of the Cauvery Aqueduct .—

Discharge to be passed through the aqueduct	...	600 cusecs
Land spans: Right side of Cauvery 2 Nos. 7'-6" x 7'-0" Reinforced Concrete Box	...	1,047 feet
Left side of Cauvery 2 Nos. 7'-6"x 7'-0" Reinforced Concrete Box	...	907 feet
River spans: 2 Nos. 6'-6" diameter steel pipes carried over 40 piers	...	1,380 feet

The photo shows the completed piers and the 9'-0" Roadway on the downstream side. The four rows of R. S. joists to carry the Twin steel pipes 6'-6" diameter have been fixed in position in a few of the river spans.

CONTRIBUTIONS INVITED.

Attention of the readers is invited to Circular No. 392/51-195 dated 26-11-1952 inviting articles and papers for publication in the New Irrigation Era. The Chief Engineer regrets that in spite of appeals and invitations, the contributions to the journal by the Officers of the Department and others have been much below expectations. The Officers of the Department, Principals of Engineering Colleges, Officers of the sister Engineering Departments in the State and others interested in the Science and Development of Irrigation are requested to contribute articles and papers in very good numbers.

For 'Instructions to Contributors' reference is invited to pages 245, 246, 247, 248 of Volume II. Copies may be had on writing to the Editor, Post Box No. 416, Chepauk, Triplicane, Madras-5.

THE NEW IRRIGATION ERA

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Madras (5) South India.

(For Departmental Circulation only)

" I believe in Hands that work,
Brains that think and
Hearts that love."

—Elbert Hubbard.

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RECOMMENDATIONS FOR GREATER ECONOMY IN CONSTRUCTION.

1. *The engineer, in preparing his design, should constantly keep in mind the methods to be used by the contractor for economical construction.*

2. *The engineer should be responsible for the accuracy of borings and other subsurface data shown on the plans.*

3. *Engineering plans should be complete and definitive, and still be kept sufficiently flexible so that they can be adapted without loss of time and, if possible, without increases in cost, when changed conditions are encountered in the field.*

4. *Interpretation of plans and specifications in the field should be entrusted by the engineer to supervisory personnel who have had practical experience with contractors, who understand the contractors' methods of obtaining results, and who have binding authority to make decisions.*

5. *Regularly scheduled field meetings should be held between the engineer and the contractor's representatives to discuss various phases of the work so that both parties can be of mutual assistance when problems arise.*

6. *Where separate, special designs are involved, they should be thoroughly coordinated in advance, with field conditions in mind.*

7. *It should be remembered that a design that appears most economical from a purely design standpoint may actually be most costly if it entails the development of special construction methods.*

—With acknowledgments to " Civil Engineering" October 1952.

EDITORIAL

CONTROL OF PROJECTS

IT has been suggested that for River Valley Projects and major irrigation schemes, a Committee of control should be appointed to be in charge of execution and to whom nearly all the powers of Government should be delegated. This suggestion has been even supported by certain men in the profession.

IN this connection, I am reminded of the saying that "if the construction of the Ark was entrusted to a Committee, the vessel will be still in progress". Many floods would have come and gone, but the Committee would be still deliberating about the work. It is often forgotten that the practical side of Engineering is not only a Science but also an Art and anything in which there is an artistic element is a one-man's job and is quite unfit to be placed under the control of a Committee.

SO far as the Madras State is concerned the execution of the various irrigation and power schemes that were undertaken like the Periyar Dam, the Mettur Dam, the Pykara Electricity System, the Tungabhadra Project and the Lower Bhavani Project, were all placed in charge of Engineers in whose professional and administrative abilities Government had full confidence. The special Revenue and Accounts Officers for these projects were appointed only under the ordinary administrative set-up of the State. The need for a Committee of experts to control the operations in the field was not felt. These works have been carried out successfully and economically and this result could not have been achieved if the organisation had been saddled with a Committee to control the day to day activities of the Engineers

concerned. A Committee, under whatever conditions it might work, cannot be expected to display the same sense of urgency and responsibility which Government themselves could be expected to show. Our experience has been that once Government decide to take up a project, they are ready to give the Engineers all facilities for carrying out the work.'

● WHILE speaking before the International Engineers' Conference at New Delhi in 1951, our present Chief Minister,—then a Minister of the Government of India—stated as follows:

> "Dealing with men, an Engineer should have the ability to co-operate, to organise, to analyse situations and conditions, to formulate problems, and to direct the effort of others. He should know how to inform, convince and win confidence by skilful and right use of facts.
>
> * * * * *
>
> Well, if we could only get Engineers of this type in India, there could be no difficulty in giving them not only all the Public Works of the Country to be done, but the whole Government of India, lock, stock and barrel."

● WELL, why not? We certainly do not aspire that the whole Government should be placed in our charge, but certainly all the Public Works in the Country should be allowed to be built by Engineers without undue interference from others. But while we claim this, let us not forget the formidable array of virtues and qualities which go to make up an Engineer.

T. S. Venkataraman

Fundamental Principles in the Design of Earth Dams

By Sri A. R. VENKATACHARI, B.E., M.I.E. (Ind), M.Am. Soc. C.E., I.S.E.

A grasp of the fundamentals involved is very essential before taking up the design and construction of earth dams. Fundamentals if properly applied will help understanding any problem that may arise from time to time during design or construction. It is these fundamental principles that I want to impress on you and get you to appreciate them properly. Guarded design and stringent construction control will go a long way to effect economy and proper execution of any work to be undertaken. In order to step up the efficiency of a job, a thorough grasp of the principles of design is necessary.

2. With the advent and progress of science on soil mechanics, there has been a recent marked trend towards building high Earthen Embankments and dams; more so, in the United States of America. So far, we have not had any high Earth Dam worth talking about. The maximum we have gone up to is about 60 feet high or so. For the present, the Lower Bhavani Earth Dam will be the highest in the Madras Province. Since we do not have any standards set up for high earth dams and as it may not always be reliable to depend entirely on a set of thumb rules, we have to give thoughtful consideration to designing of our Earth Dams. We can gain much by experience and available standards and data set up in the United States of America in building these dams. But at the same time, we should not lose sight of the fact that we have to design them particularly to suit our conditions and our economy.

3. The marked swing towards high earth dams in the recent years is explained by more than one reason. An earth dam is comparatively cheap. It can be built almost on any foundation and with the available materials at site. For instance, by going in for an earthen dam in the Lower Bhavani Project, there has been a savings of about 50 lakhs of rupees. With adequate investigation of the nature of foundations, proper selection of the materials, adoption of designs to suit the above and by an organised vigorous construction control, earth dams can be built almost anywhere. A detailed study of the various problems involved should be taken up before hand.

4. ***Construction and design aspects:***—The Construction operations can be divided into two parts:—

(1) Mechanised construction.

(2) Manual labour construction.

Each of the above has its own merits and disadvantages so far as we are concerned. For short leads and small lifts manual labour is still useful and perhaps also cheaper. For long hauls and high lifts machinery should prove economical. More than all, construction by manual labour provides employment for lot of people. We have to particularly consider this aspect and plan our construction programme. However, what we should aim at is a co-ordination of both mechanised equipment and manual labour. The great obstacle to getting all the machinery we want is the present dollar shortage. So we have to limit our purchases in the hard currency areas especially the United States. This fact alone should force us to get only the essential and limited amount of machinery and supplement the rest with manual labour. I for one would rather buy a number of small machinery than a few big ones for almost the same buying price. This idea will come in very useful when there happens to be any breakdown since we cannot afford to have a stockpile of useless machinery. As far as this project is concerned, some of the earthmoving equipment you will come into contact are, excavators, dumpers, scrapers, bulldozers, graders, tractors and the most familiar track-lines and wagons hauled by locos.

5. ***Design:***—One of the factors we have to take into consideration in designing an earth dam, is percolation. A study of the character and structure of the soil should be known to understand characteristics of percolation. The soil structure is composed of solid particles and voids. The voids are filled with air and water.

The natural soil consists of solid particles and voids that are filled with water and air. (Even the so called saturation clays will contain very small quantities of free air in the form of bubbles.) It could be diagramatically repre-

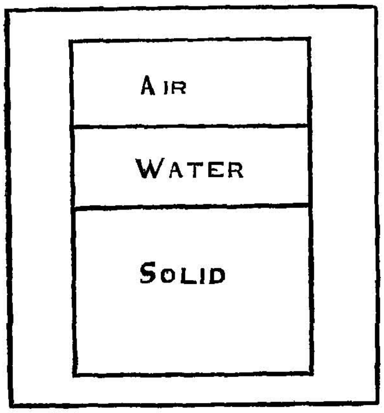


Fig. 1

sented as shown in Fig. 1. When the soil is compacted, the solid particles rearrange themselves and may deform elastically without significant change in volume. The air above is compressed and the voids become smaller. There is however intercommunication of the individual voids forming a series of tubes. These series of the tubes offer paths of percolation. The tubes need not be straight and they may vary widely in their sizes. They range from very small to appreciable sizes. The diameters may depend upon various factors such as amount of compaction and consolidation, the gradation of the particles, the grain structure of the particles etc.

6. In an earth dam, whether it is of homogenous section or zoned section, there are a quite a number of these 'tubes' through which water from the dam percolates. The water percolating through the embankment appears on the downstream side and if the velocity or pressure head of this seeping water is high it may carry away part of the embankment material and will decrease the resistance to percolation and the resulting increased flow will cause erosion forming bigger channels or pipes through the embankment structure. The rapid enlargement of this pipe will cause sloughing at the downstream side and there will be consequent failure of the structure. Also when the dam is constructed on other than impervious foundation, there is the possibility of piping underneath the dam in foundation zone and the subsequent sudden failure of the structure.

7. There is another possibility of failure due to poor drainage. When there is a rapid draw down as in the case of Irrigation reservoirs during the particular season, water percolates from inside the embankment outwards and the embankment may fail by shear. Though this condition is not very common, we have to consider this also for a safe design.

8. Water percolation through the dam through different channels or paths of percolation may be visualised by a simple analogy. Suppose there is a grid having different pipes of varying diameters as shown in Fig. 3 When water

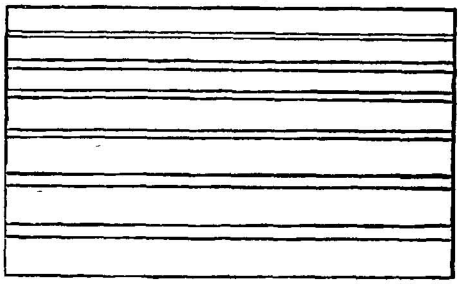


Fig. 3

is allowed through this grid it will flow through the pipes with different velocities. Similarly, imagine the earth dam is composed of pipes of different diameters. When water is stored it will percolate through these tubes, with varying velocities. We should design the earth dam so that

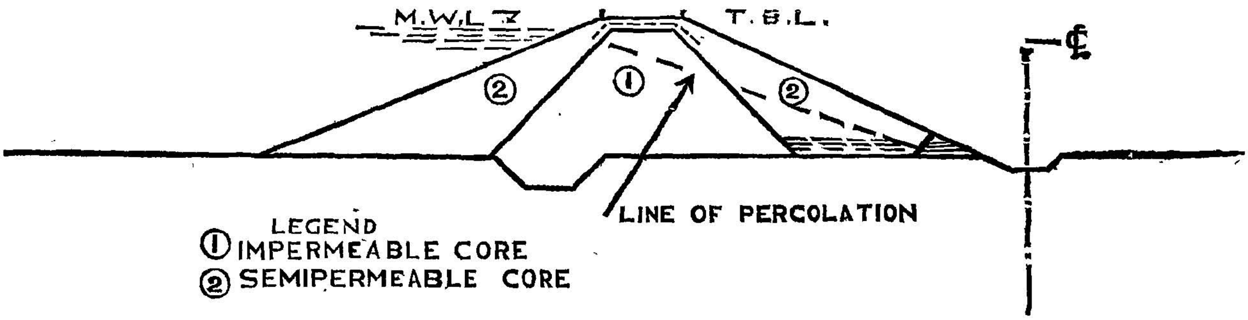


Fig. 2

the material is safe against piping velocity at the downstream side through the foundation and is not displaced from the place it occupies. The path of percolation is therefore increased, thereby increasing the length of the pipe and its resistance and lowering the velocity for the available head.

9. ***Piping:***—Percolation can be reduced to a safe limit by providing an impervious blanket on the upstream side. The blanket increases the percolation distance and provides a material having smaller passages through it, owing to smaller sizes of particles, and causes a greater loss of pressure head before the point of emergence is reached. The increase in the path of percolation, or reduction in sizes of passages through the material, decreases the velocity and amount of seepage and reduces the possibility of piping or blow outs.

the coarser filter material without removal of the fine material. Even though there may be appreciable amount of seepage and a velocity high enough to move small particles, it will not cause piping, if the filter is properly designed. The outer slopes can be flattened by dumping rock and adequately weighting down the foundation. The flattening of the outer slopes also adds to the stability of the dam.

12. We have to provide against burrowing animals and rodents. Many earth dam failures have been attributed to these. I have initiated some research schemes to study these aspects. In one case, coursed rubble stones built in clay or same materials as the core are put in adjoining the central impervious core slightly on the upstream side. The idea is even if jackals and burrowing animals try to put in a hole, they will be unable to get through the stone wall. Another

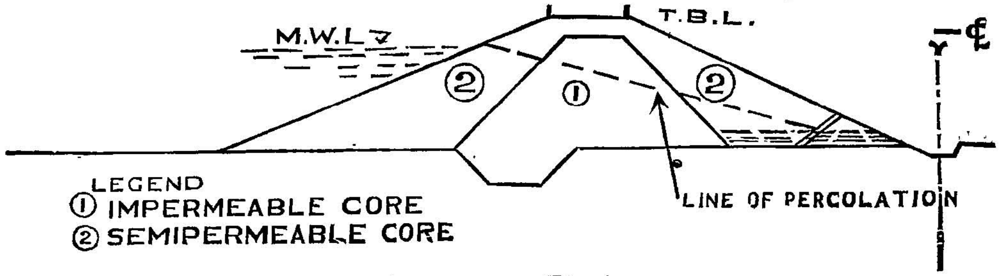


Fig. 4

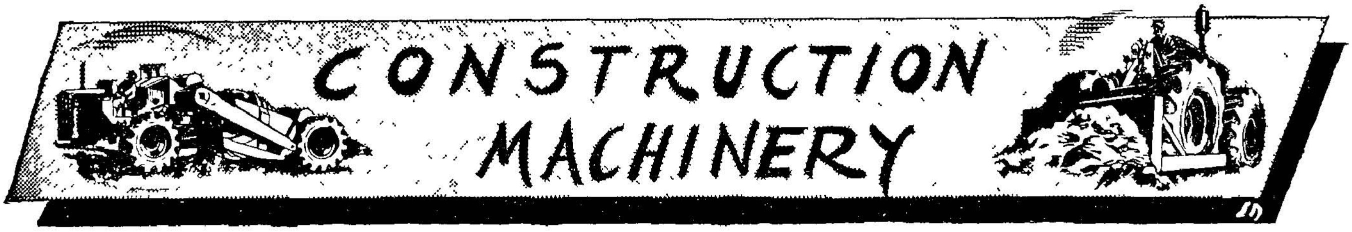
10. A cut off trench in the upstream side of the dam is provided to shut off some of the lines of percolation. The cut off trench is taken to rock or an impervious stratum. The cut off trench serves the same purpose of increasing the creep distance and reducing the amount of percolation. When the cut off trench is taken upto rock level, it is usual practice to build a central cut off wall for keying in. The cut off wall may be of concrete or masonry and taken 2′ to 5′ into rock. It may even extend 5′ to 10′ into rock. It may extend 5′ to 10′ above rock level depending on the design.

11. Another way of making the dam safe in a pervious foundation is by the construction of an inverted filter on the downstream toe. The filter consists of a bottom layer of fine material surmounted by other layers of progressively coarser materials. Water passes through the fine material towards coarser material. The filter is so designed that the water seeping beneath the dam passing through fine material is passed into

kind to be tried is a sand bed or broken stone instead of the embankment material behind the revetment. These will slip and collapse and prevent burrowing animals making a hole.

13. There has been some difference in opinion about the height to which the central impervious cores should be taken. Some designers take it right upto the top of dam. There is no trouble encountered in this case. Some just take it about 2 or 3 ft. above M.W.L. I suggested some model studies be made about this. These studies showed that when water was passed through a zoned section of the model, I found a fair amount of water passed over the top of the impervious core. This is due to the capillary syphonage action over the core top. So, when the top of the central impervious core is not taken up to the top level of the dam, we should be careful to see that it is taken to a safe level having regard to the capillary height for the particular class of soil so as to prevent losing a great deal of water by capillary action.

" A Lecture delivered before the Technical Club, Bhavanisagar on 9—7—1949.



The Diesel Engine

Contents.

(1) Discussion; (2) Description; (3) Generation of Power; (4) The Clutch; (5) Transmission of Power; (5) The Transmission; (7) The Universal Joint and Shaft; (8) The Final-Drive to Rear Axles; (9) Overhaul; (10) Tune-up; (11) Starting Engines; (12) Steady Load.

1. **Discussion**:—The Diesel engine was developed in Germany because of the lack of gasoline in that country.

This type of engine attained popularity in the United States because power could be developed with a low cost fuel oil. Even though the original investment was much more than that for a gasoline engine, the savings in fuel cost was considered to be enough to offset the higher investment and save operating fuel costs beyond the extra investment in the original cost.

Diesel engines when first introduced to this country were large and heavy, requiring permanent concrete bases in most installations. They were used for generating electricity, turning rock crushers and other heavy machinery requiring a steady power load. This steady pull on the engine eliminated to a large degree the most troublesome feature of early Diesel engines, the fouling of fuel injector nozzles by carbon resulting from insufficient burning of fuel explosions.

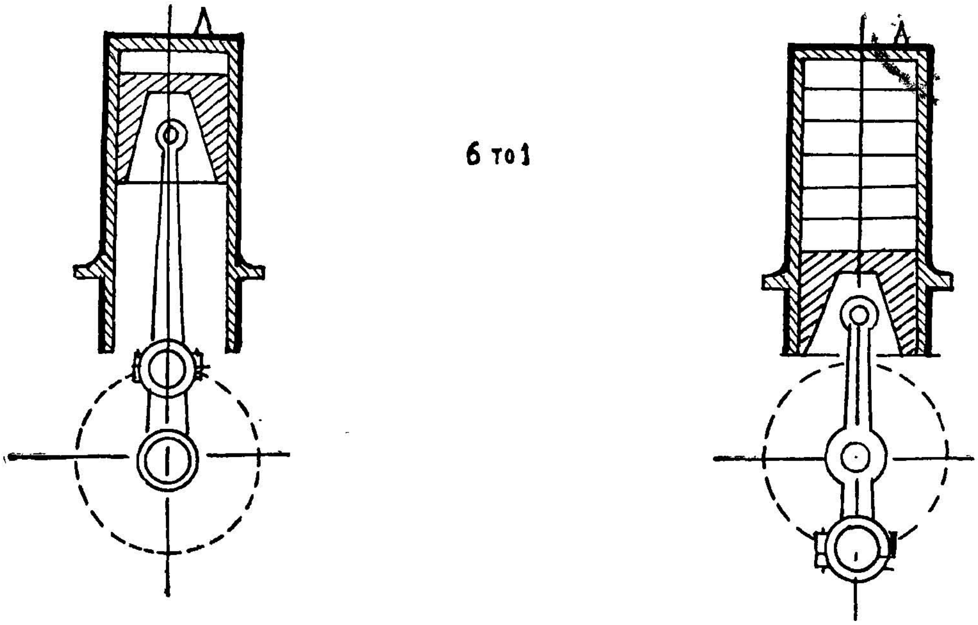
When Diesel Engines of lighter design were first used on construction equipment, the intermittent light and heavy demands for power caused fouling of injector nozzles and consequent delays for cleaning and adjustment. These delays were more frequent on equipment like cranes and shovels when loading was not constant. On tractors working with more steady loads, the first Diesel engines proved more successful.

The first light Diesel engines (one-hundered and twenty-five to two-hundred and twenty horsepower) were successful on trucks and truck trailer combinations used for long distance hauling—due again to the steady load on the engine.

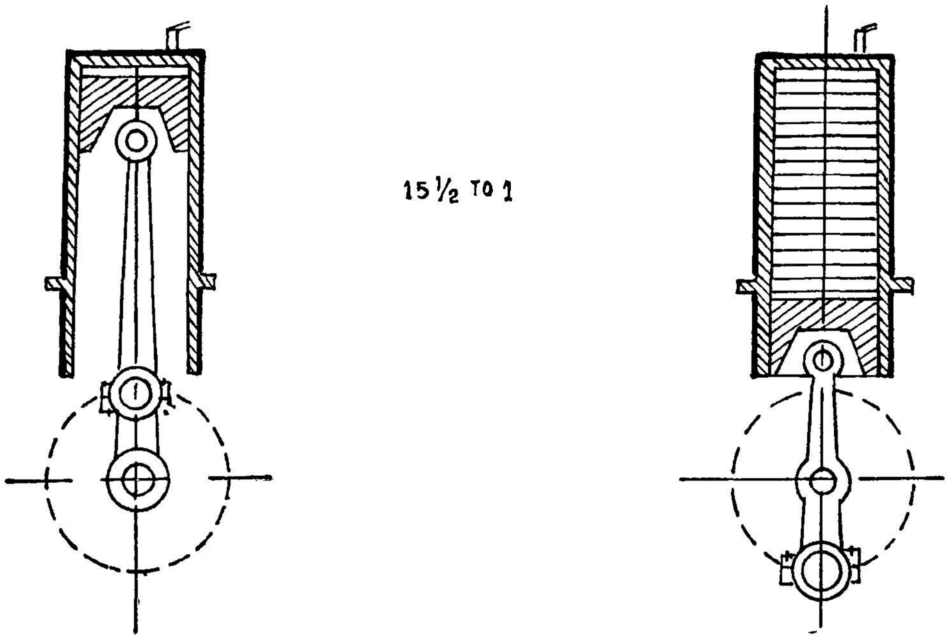
Diesel engines are built sturdier than gasoline engines and under comparable working conditions last longer. This fact, and savings in fuel costs, therefore, result in cheaper cost of operation when the Diesel engine is considered to better fit the job. The users of automotive and construction equipment determine when Diesel engines better fit the job. This is proved by the demand for equipment in which the purchaser has the option of gasoline or Diesel engine.

2. **Description**:—The Diesel engine is similar to the gasoline engine in all respects except the firing principle. In contrast to the electric spark plug in gasoline engines, in the firing principle of a Diesel engine the piston compresses clean air on the upstroke of the piston to such a high temperature that when fuel oil is injected at the right moment an explosion occurs. This drives the piston down and subsequently pushes the connecting rod attached to the main crank shaft. All Diesel engines are similar in their combustion process as described above. They are different in their starting devices in that practically all manufacturers of Diesel engines use a different method for starting the main Diesel engine.

3. **Generation of Power**:—The power of the Diesel engine is generated when the fuel oil, under pressure of 3,000 pounds per square inch or upward, is injected at exactly the right instant as the piston travels toward the cylinder head.



The gas engine cylinder and piston showing approximately the 6 to 1 compression ratio usually used for gas engines.



The Diesel engine cylinder and piston showing approximately the 15½ to 1 compression ratio usually used for Diesel engines. The highly compressed air explodes when oil is injected (about one drop) at the moment that the top of piston is closest to cylinder head.

The oil and air become thoroughly mixed just before the highest compression point is reached, which is when the top of the piston is closest to the cylinder head and the oil injector needle valve and the exhaust valve have both closed. It is this high compression which causes the explosion. Each cylinder has its own fuel oil injector nozzle and exhaust valve—each cylinder does its own work load. The timing of oil injection must be accurate in order to obtain maximum power.

The generation of power in the Diesel engine depends almost entirely on proper functioning of the fuel oil injector nozzles which must be timed as precisely as possible, and kept clean. Because of this, mechanics, who are engaged to work on Diesel engines, should be given special training and instruction by manufacturers' representatives. Diesel engines are under constant development and experienced instructors have access to a great deal of information about Diesel operation which has been learned from many sources. The mechanic in an isolated location is not always aware of new developments or tricks of the trade discovered by old timers.

Horsepower of Diesel engines is determined by size of cylinders and pistons. Diesel engines usually have two, four, six and up to eight or more cylinders of the two or four cycle type. The number of cylinders used provides enough variation in horsepower to accommodate present-day automotive and construction equipment.

4. **Transmission of Power**:—When the Diesel engine is warmed up enough to produce its maximum power it must overcome its starting load by the use of a clutch and transmission. On automotive and construction equipment this is done in the same manner as with the gasoline engine. However, on many kinds of construction equipment, the design is such that the transmission assembly is not always next to the clutch housing. This is because the machine requires in its design, a transmission assembly in a different position than that which is usually found on most over-the-highway equipment. It does not make any difference where the transmission assembly is located, it will be needed to reduce the speed of the engine and consequently increase power for starting the load. (The only exception to this might be where a Diesel engine turns a sawmill, an electric generator or water pump.) The manufacturers of Diesel engines work closely with automotive and construction equipment manufacturers in order to produce the most effective type of transmission device for the particular type of equipment in which the Diesel engine is to be used. This can be seen where the same make of Diesel engine is used in a truck, a revolving shovel, a tractor or a sawmill.

5. **The Clutch**:—The Diesel engine clutch is of the same conventional design as that used for gasoline engines and is usually of the single disc dry plate type. Different manufacturers have developed clutch improvements which assist in taking more easily the first torque, or starting load, when engaging the clutch. On construction equipment reference is made to the master clutch. This is because in addition to the main engaging clutch (engine shaft to transmission) there are other clutches for engaging the various mechanisms which make a complete operating machine; like steering clutches on tractors, clutches for hoisting drums and clutches for power take-off auxiliary equipment.

6. **The Transmission**:—Transmissions of Diesel engines reduce speed and increase power of the shaft which in turn drives the working load. Diesel engines develop high horsepower and therefore are capable of moving heavy loads and turning heavy machinery. In order to effectively start heavy loads, Diesel engines of high horsepower have transmissions with a greater amount of range than is found in conventional gasoline engines. Greater amount of range in the transmission means that gear ratio is reduced many times so that the power can be exerted at a low speed. Power is increased by gear-reduction. It is customary, therefore, to have shift ranges far beyond the first, second and high of conventional passenger cars. There may be up to eight ranges of speed forward and more than one reverse speed.

Diesel engines are used extensively on heavy types of automotive and construction equipment and therefore the transmission will be heavier, larger and contain more gears for producing different speeds.

7. **The Universal Joint and Shaft**:—The universal joint and shaft takes many forms in

construction equipment, and modern buses with engine mounted in the rear. Regardless of how the power is taken off the main engine shaft, (through clutch) it will usually be found that between the transmission assembly (always in a fixed position) and the driven working unit (axle or shaft) there will be a universal joint and shaft. This is because all automotive and mobile construction equipment is subjected to change of position. By change of position is meant that the chassis, frame or structural members move up and down or sideways. This is not true of stationary equipment mounted on foundations.

8. **The Final Drive to Rear Axles**:—When Diesel engines are used in trucks, buses or construction equipment the final drive to rear axles embraces the same principles as the gasoline engine powered equipment. There are special final drive systems for different types of equipment. In practically all cases a pinion or pinions drive a ring gear, or chains and sprockets drive the final axle or shaft. Almost all working parts of automotive and construction equipment turn at a speed fast enough to require pinions and ring gears, chain and sprockets, or small gear with large gear. In certain instances the wormgear is used so as to hold the load. Example: Raising and lowering booms on cranes or derricks.

9. **Overhaul**:—Overhauling of Diesel engines is similar to that of gasoline engines except for two very important items, the fuel injection system and the timing. Pistons, cylinder linings, connecting rods, bearings and the main crankshaft of Diesel engines have the same general characteristics as gasoline engines. Some manufacturers use the same bore and stroke in Diesel engines of a "series", having various numbers of cylinders. Thus in an engine of a certain series, the parts are interchangeable, regardless of number of cylinders. This reduces parts-on-hand stock for servicing all engines of one make and series. The principles of fuel injection and timing are intricate, however, and the gasoline engine mechanic should have actual instruction by a qualified Diesel mechanic or manufacturer's representatives before being permitted to work alone on a Diesel engine. In instances of large fleets of equipment using Diesel engines it is good practice to develop a Diesel mechanic by having him work with experienced Diesel mechanics.

10. **Tune-up**:—Many users of equipment with Diesel engines have modern equipment for testing the fuel injection pumps which force fuel oil into the cylinders. Tune-up of Diesel motors to maximum efficiency can be achieved by using testing equipment for setting fuel injector pump pressures. Tune-up of a Diesel engine is related almost entirely to the fuel injection system with its consequent timing system. In the field there can be observed a lack of proper tune-up. Operators adjust injector pumps by guessing, sense of hearing, bark of the exhaust and color of exhaust fumes. Field equipment should be serviced by mechanics possessing proper tools and testing equipment.

11. **Starting Engines**:—The different methods of starting a Diesel engine are:

(*a*) A separate gasoline engine of light horsepower which turns the Diesel engine until high compression is reached and explosions take place in the Diesel cylinders.

(*b*) Using batteries to turn the Diesel engine.

(*c*) Combination systems using gasoline to start Diesel engine running.

(*d*) Using compressed air to turn the Diesel engine.

(*e*) Cranking with exhaust valves open.

The different types of starting system on Diesel engines are important in regard to climate. In warm climates starting is not difficult but in section of the country where temperatures are extremely cold and equipment is to be idle overnight, the starting system should be considered when purchasing equipment powered by Diesel engines. This is because the Diesel engine must be turned rapidly enough to create a high temperature in the cylinders so that an explosion occurs when fuel oil is injected into the highly compressed air in the cylinder.

12. **Steady Load**:—A steady load for a Diesel engine can be considered a truck, truck-trailer or bus operating between cities, towns or villages, or a distance of several miles between stops. However, Diesel equipped buses can be seen operating efficiently on local routes in many cities and towns. The same is true of Diesel powered trucks and truck trailers. According to truck registrations, the choice of gasoline or Diesel engines on short routes is indicated by the

ratio of Diesel-to gasoline powered truck registrations and represents the owners thinking on which is more economical to operate. A heavy truck moving with congested traffic during the working day in New York, Philadelphia or Chicago would be forced to stop and start as many as five times in one city block—this is not considered a steady load. When a truck can move out on an open traffic lane and keep moving, then it is considered as pulling a steady load. This is why over-the-highway buses and freight carriers use the Diesel engine—it pulls a big load easier and the cost is less in operating fuel.

Steady loads in other kinds of equipment using Diesel engines are: Sawmills, power shovels, tractors, earth movers, road graders, rock crushers, pumps, asphalt plants, welders, oil drilling machines, boats, dredges, mining, logging, irrigation pumps, gold mining and generating electricity.

With acknowledgments to "Automotive and Construction Equipment," By C. W. Lindgren.

PROGRESS OF RESEARCH WORK IN MADRAS.

(Continued from Page 16.)

Solutions for the exclusion of silt from canal were obtained in the case of

(i) Kattalai high level channel ;

(ii) Tirukkoilur anicut across the Ponniar;

(iii) Pennar, Kumudavati canals etc.

In the Figure is illustrated how the simple artifice of suitably orientating the divide wall, enables the exclusion of under currents carrying the bed silt from the offtaking canal.

Experiments were also carried out in connection with the remodelling of a number of tank weirs of trapezoidal form when the necessity to increase the discharging capacity in some cases and to raise the full tank level in other cases was felt. Both these objectives were simultaneously accomplished by evolving suitable stream-lined crest shapes with high values for co-efficients of discharge, to be built on the top without disturbing the existing sections of trapezoidal form.

(To be Continued)

Progress of Research Work in Madras

A. Irrigation Research Station, Poondi, Madras (1944-52)

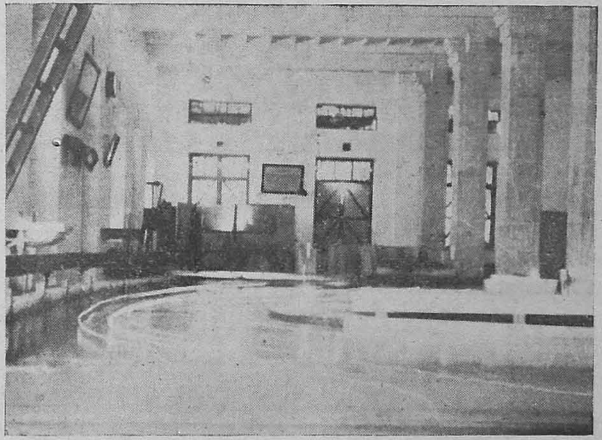
(Continued from previous issue)

4. Nature of Studies Conducted.

As mentioned earlier the work in the Irrigation Research Station principally consists of experimentation by employing small scale hydraulic models. The question is often asked, as to how, the results on small scale models of spillway dams etc., 3 or 4 feet high in size could be relied upon to judge the performance of structures as high as 100 feet and above. It is further asked, as to whether, every dimension of the structure in nature, including size of sand in the river bed, are to be reduced to scale in the model. These are purely technical questions for which exhaustive explanations could be given. For the present purpose, suffice it to say, that the similarity of performance observed in experiments on models to different scales, and also a comparison of observations on the models and the structure in nature, in various hydraulic research laboratories throught the world, have established the fact that the hydraulic model could be reliably used as a tool in design, provided the model is constructed and operated, in accordance with certain criteria and the results of study are interpretted with proper allowance for its limitations. The fact may also be noted that the model need not be an exact replica of the prototype in a geometrical sense, which implies reduction of sand particles also to scale but the governing principle is that, the model while it may not always look like the prototype, it must be capable of acting in the same way. Once this has been accomplished, it is possible to analyse, or predict the flow conditions of a given fluid, in one hydraulic system, namely the structure in nature (*i.e.*, the prototype) from knowledge of the flow of the same or another fluid in a similar system of smaller dimensions *i.e.*, the model.

The number of problems for which solutions have already been furnished from the station by model experiments exceed 90. A brief description of important problems is furnished below to illustrate the complications involved in the problem, the artificies employed in its solution, the savings in cost and the value of knowledge acquired in the solution of similar problems in the future without recourse to experiments. The fact should, however, be stressed, that the examples of savings in cost furnished below are intended to be illustrative, and not exhaustive.

(1) *Flood Diversion by Coffer Dams*:—In the Ramapadasagar dam across the Godavari, the proposals for flood diversion consisted of building a cellular sheet pile coffer dam, restricting the water-way to about one half the normal width of the river. Experiments were conducted on

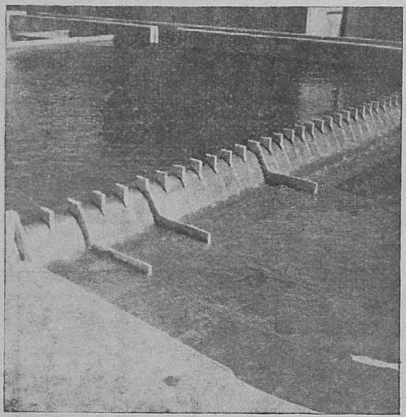


Ramapadasagar Cofferdam. Stream lines traced by candle floats

models to scale 1/300 and 1/150 geometrically similar in an effort to (i) determine the heading up of water caused by the coffer dam so as to fix its top elevation suitably avoiding overflow (ii) estimate the maximum depth of scour which may be caused at the foot of the cells forming the cofferdam and (iii) evolve a suitable alignment for the coffer dam in an effort to throw the deep scour far away from it.

(2) *Spillway dams—Energy dissipation in rear*:—Suitable designs were evolved for energy dissipation arrangements in rear of spillway dams of the Ramapadasagar, Thungabhadra, Lower Bhavani and Malampuzha dams. The features of foundation materials, and tail-water elevations

being different in each case, separate solutions particularly suited to the conditions obtaining had to be evolved. For example in the Ramapadasagar dam, the sub-surface rock was available at about 150 feet below the sandy river bed and the tail water depth was large and in this situtation the design for a roller bucket resting on the dam face was evolved in which energy is destroyed by hydraulic friction since conventional devices involving long aprons and staggered blocks proved too expensive for the situation



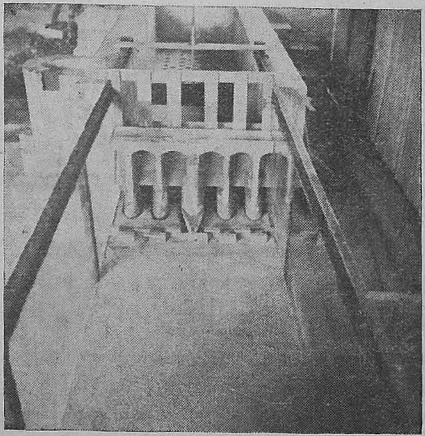
Thungabhadra spillway dam, 3 dimensional model

as they required a separate foundation of their own, for the reason that rock was not available near the surface. On the other hand, in the case of the Thungabhadra and Malampuzha spillway dams, where hard rock was available at river bed level, no elaborate dissipating arrangements were recommended as considered unnecessary and thereby savings in cost were effected. For example in the case of Malampuzha dam the savings amount to about Rs. 1,20,000. The investigations regarding the design of stilling basin, for the Lower Bhavani Dam led to the evolution of a new type of energy dissipation device, which will be referred to subsequently. The studies were carried out on part-width or sectional models as they are called, fitted inside parallel sided glass flumes and also masonry flumes and the final solutions were tested on comprehensive *i.e.* 3 dimensional models.

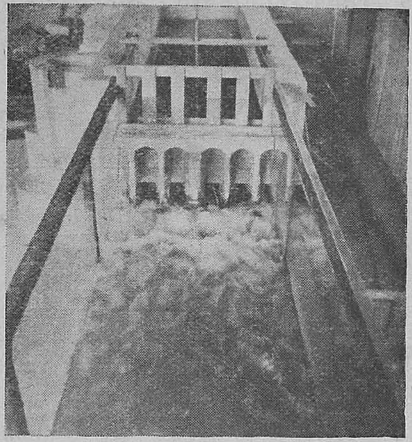
(3) *Coefficient of discharge of spillway dams*:—In fixing the length of the spillway dam of the Thungabhadra, the coefficient of discharge of the spillway as well as the effect of shape of cutwaters of piers on the coefficient was sought for. The particulars were derived employing the principles of extrapolation and conducting experiments on models to scale of 1/12, 1/24, 1/48 and 1/96.

(4) *Negative pressure on the profiles of spillway dams*:—In the design of an overflow dam, the profile should be such that, no negative pressures are developed on the surface of the dam by the overflowing water, for, such pressures set up vibrations on the dam and cause pitting of the surface. Hence usually the shape of the undersurface of a freely falling jet of the dimensions of the overflowing stream is given for an Ogee dam. The profiles of Ramapadasagar, Thungabhadra, Lower Bhavani and Malampuzha spillway dam were tested for negative pressures by piezometor set-ups on hydraulic models and suitable curves recommended.

(5) *Design of training walls of spillway dams*:—In the case of Ramapadasagar and the Lower Bhavani spillway dams, the design of training walls introduced problems of their own, which were successfully solved by model expriments. For example in the Lower Bhavani Dam, the river sluices were located in the deep course of the river, while the spillway dam is located on the left flank with a heavy overburden in its rear. For guiding the flood discharge from the spillway through the bridge across the river downstream, as a result of studies on a comprehensive model to scale 1/72, the design for the left flank



Head sluice of Kistna-Pennar main canal.
Model in glass flume



Head sluice of Kistna-Pennar main canal
Initial condition of flow

training wall as evolved, which involved the least amount of cutting of the overburden in rear of the spillway, without impairing the hydraulic efficiency. The savings in cost on this work owing to the model experiments was estimated to be Rs. 1,75,000.

(6) *Design of sluices* :—In the case of sluices in dams the problem resolves itself into two parts *viz.*, (i) design of streamlined inlet curves to ensure cavitation-free operation and the design of energy dissipation arrangements in rear. Problems relating to the energy dissipation below Siddeswaram and Ramapadasagar dams, cavitation free design of the inlet curves of the Thungabhadra hydraulic penstocks and both the inlet and exit designs for the sluices in the Lower Bhavani Dam and the Head sluices of the Kistna-Pennar main canal were worked out in the Research Station, by the help of hydraulic models.

Model experiments were conducted, for increasing the discharge through the Sitanagaram headsluice in the Kistna Delta and a simple artifice consisting of fitting a streamlined sill on the existing breast-wall was recommended, which increased the discharge by about 15 per cent. Thereby the need for an auxiliary headsluice contemplated costing about Rs. 2 lakhs was obviated.

(7) *Earth dams - Seepage Studies* :—In the case of Lower Bhavani Earth Dam a number of studies were conducted by experiments on seepage model to determine,

(i) The minimum section of hearting material to ensure effective seepage reduction;

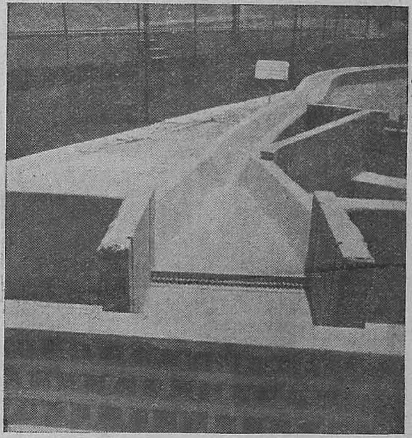
(ii) the optimum position for the cut-off trench;

(iii) the efficacy of partial cut-offs;

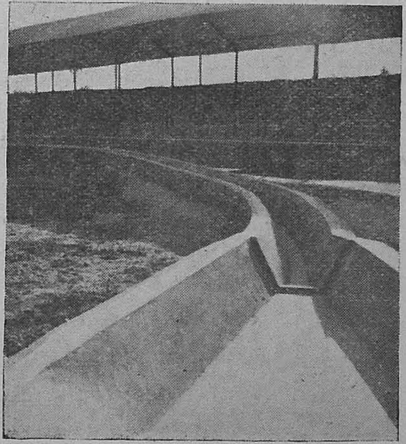
(iv) the utility of clay blankets and sheet-pile cut-offs, in ensuring seepage reduction etc.

Although, these studies were conducted for the Lower Bhavani dams, the results have a basic value and hence will be useful for application to the design of any other earthern dam.

(8) *Fluming of canals* :—In various Irrigation Projects the problem occasionally arises of taking a canal across a ridge. In such cases, fluming *i.e.* reducing the width is resorted to, in an effort to minimise the cost of excavation although the velocity thereby increases for it is not objectionable, the material being rock. An outstanding example is the fluming of the Kistna-Pennar main canal of 75,000 cusecs capacity

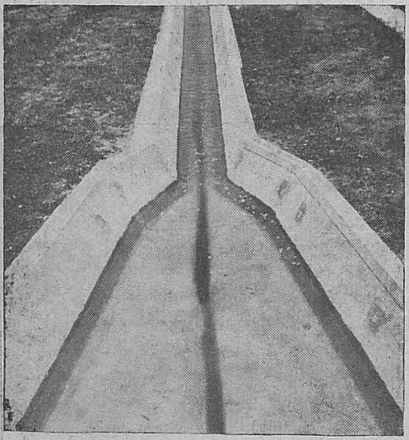


Fluming through Mittakondala Ridge—Head Reach



Fluming through Mittakondala Ridge—Tail Reach

through the Mittakondala ridge, for a length of 4 miles separating Kistna and Pennar valleys. Considerations of economy of rock cutting have led to the adoption of the alignment for the flumed portion along a curve instead of a straight line. In the design, a maximum velocity of 12′ per sec. in the throat and a maximum depth of flow of 60′ were permitted. Model experiments have established the fact that the design would function satisfactorily. This is a work estimated to cost about 6.4 crores of rupees. In the absense of confirmation by model experiments allowing a depth of flow of 60′ and velocity of 12 feet per sec. should have been considered as bold, since they were unprecedented and a more conservative design should have costed a few crores more.



Fluming through Mittakondala Ridge—
Flow features in the head reach

(9) *Design of Anicuts* :—With regard to the design of anicuts the problems involved may be described under (i) provision of high coefficient weir profiles of the Ogee form with suitable stilling arrangements in rear, in lieu of the conventional designs of trepezoidal weirs with stepped aprons etc. and (ii) exclusion of silt from the headsluices of canals. The following are some of the important high co-efficient weirs for which the designs of crest profiles and energy dissipation arrangements in rear were finalised in the Station, *viz* :

(i) High co-efficient weir across the Pennar in the Pennar-Kumudavathi project ;

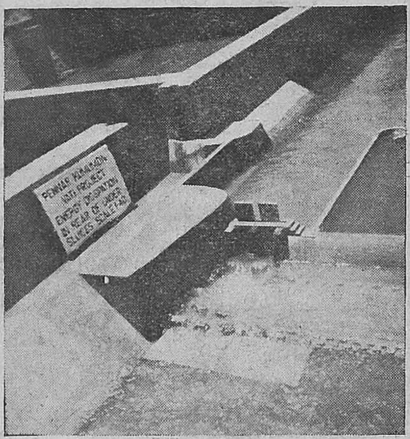
(ii) Bed-Regulator across the Cauvery at Jederpalayam ;

(iii) Uttiramerur anicut across the Cheyyar in Chingleput District ;

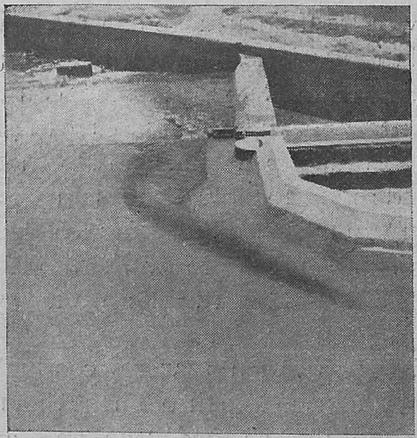
(iv) Ellis Choultry Anicut across the Ponniar in Villupuram district ;

(v) Anicut across the Boggeru in Nellore Dt., Etc.

These designs worked out much cheaper than the conventional trapezoidal weir, or the glacis with baffle wall and aprons, similar to that of Poondi Regulator.



Pennar-Kumudavati weir and under-sluice—
Energy dissipation in rear



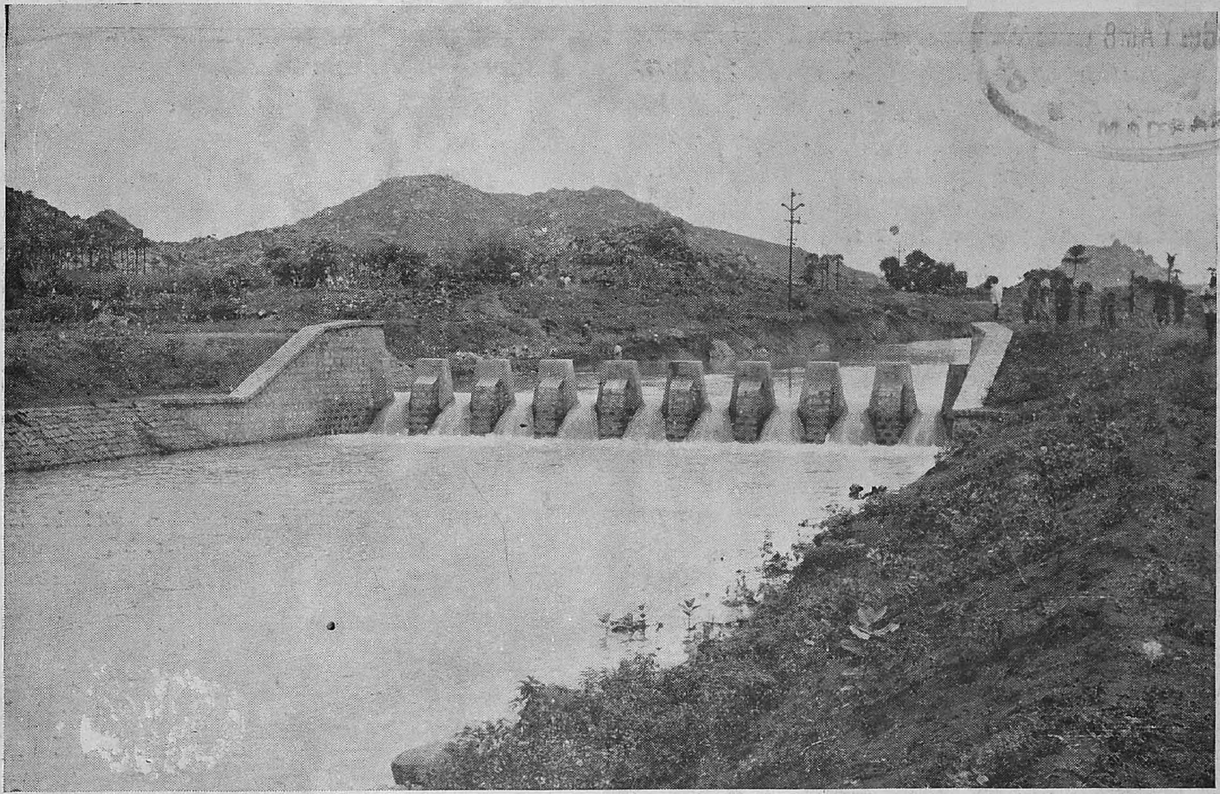
Pennar-Kumudavati—Silt exclusion from the
right flank canal

For the protection of the aprons in rear of the Godavari anicuts, on which periodical expenditure is being incurred for the maintenance, suitable devices evolved by model experiments consisting of R. C. trellis work have been recommended which would serve to both protect the aprons structurally and also effect thorough energy dissipation in rear and savethe periodical expenditure.

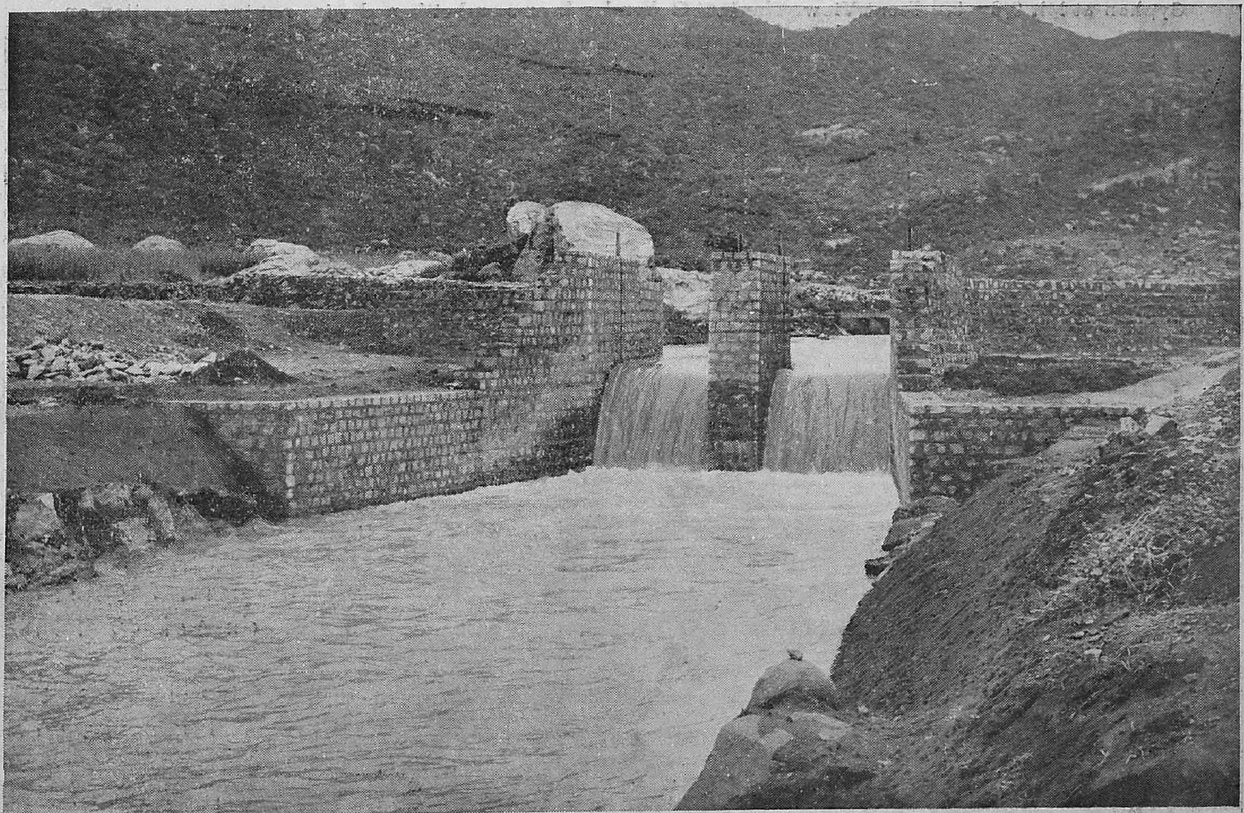
(*Continued in Page 12.*)

Mettur Canal Scheme

SALEM DISTRICT, MADRAS STATE



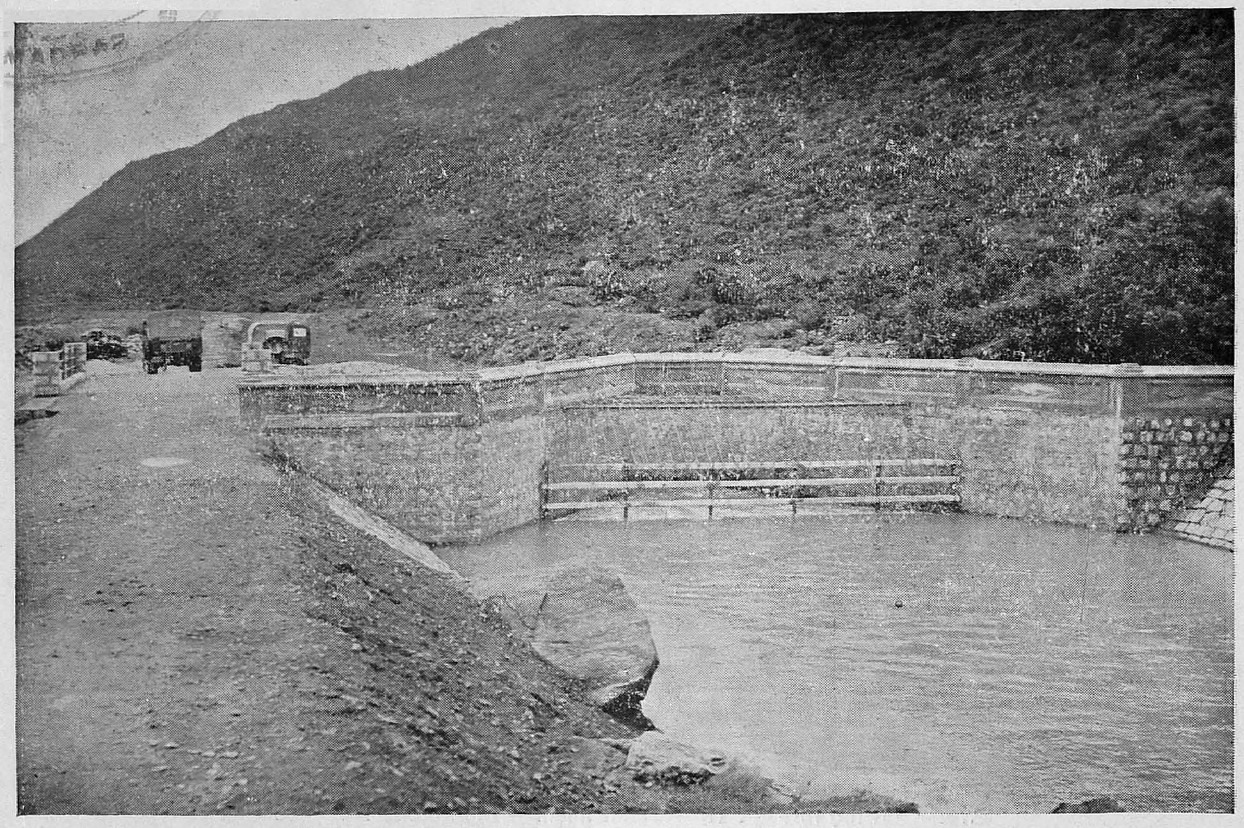
Water flowing through Trapezoidal notched Drop at Ml. 2/2 – 400′



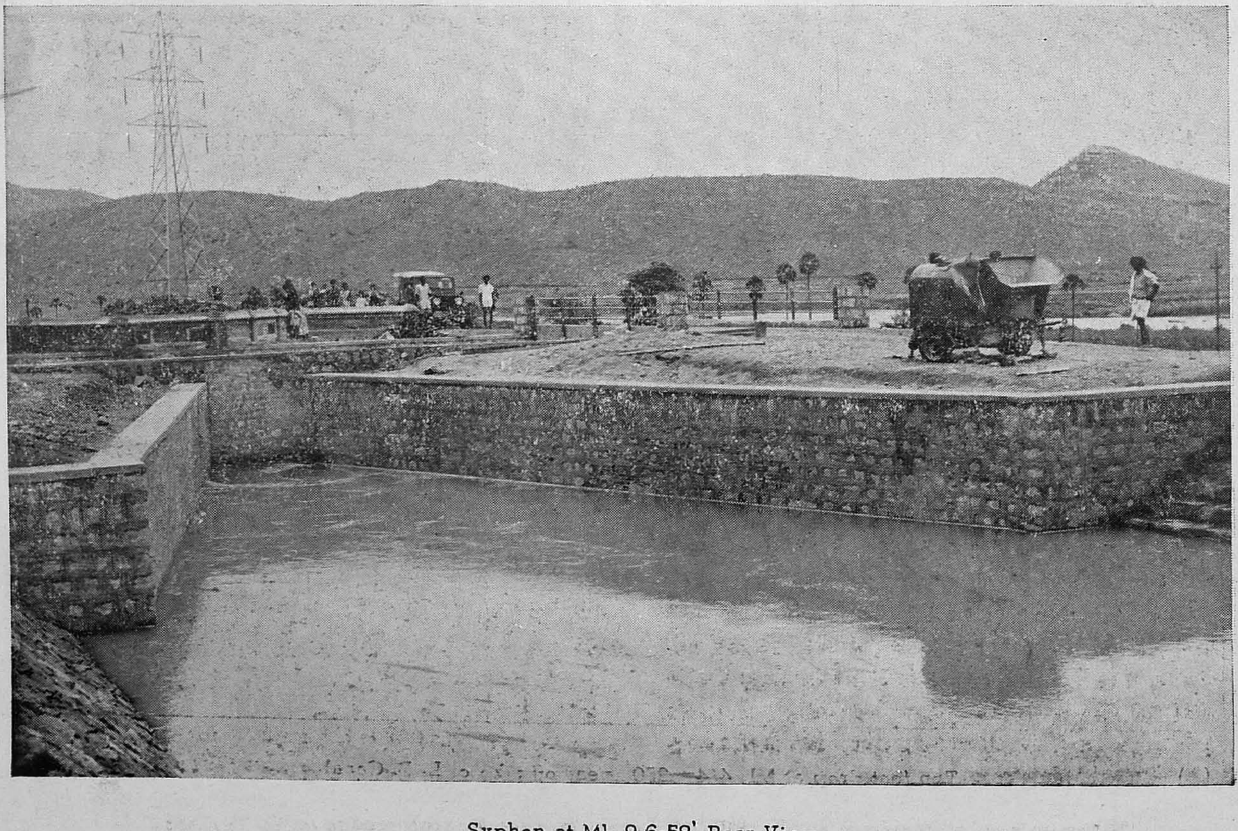
(A) Ten feet drop at Ml. 4/4—250′ near off take of L. B. Canal.

Mettur Canal Scheme

SALEM DISTRICT, MADRAS STATE



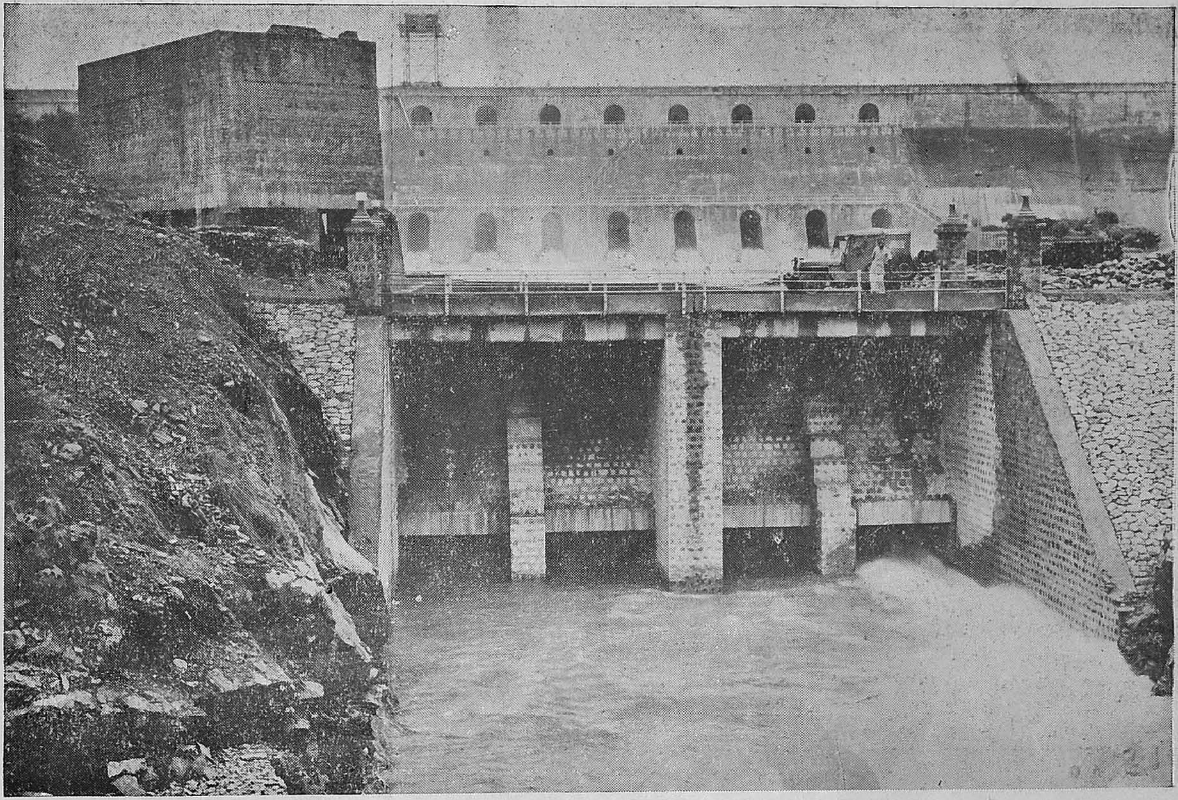
Syphon at Ml. 9/6—58' Front View. The R.C C· Fender Beams and stiffened wire netting protection on upstream side are fixed in position.



Syphon at Ml. 9,6·58' Rear View

Mettur Canal Scheme

SALEM DISTRICT, MADRAS STATE

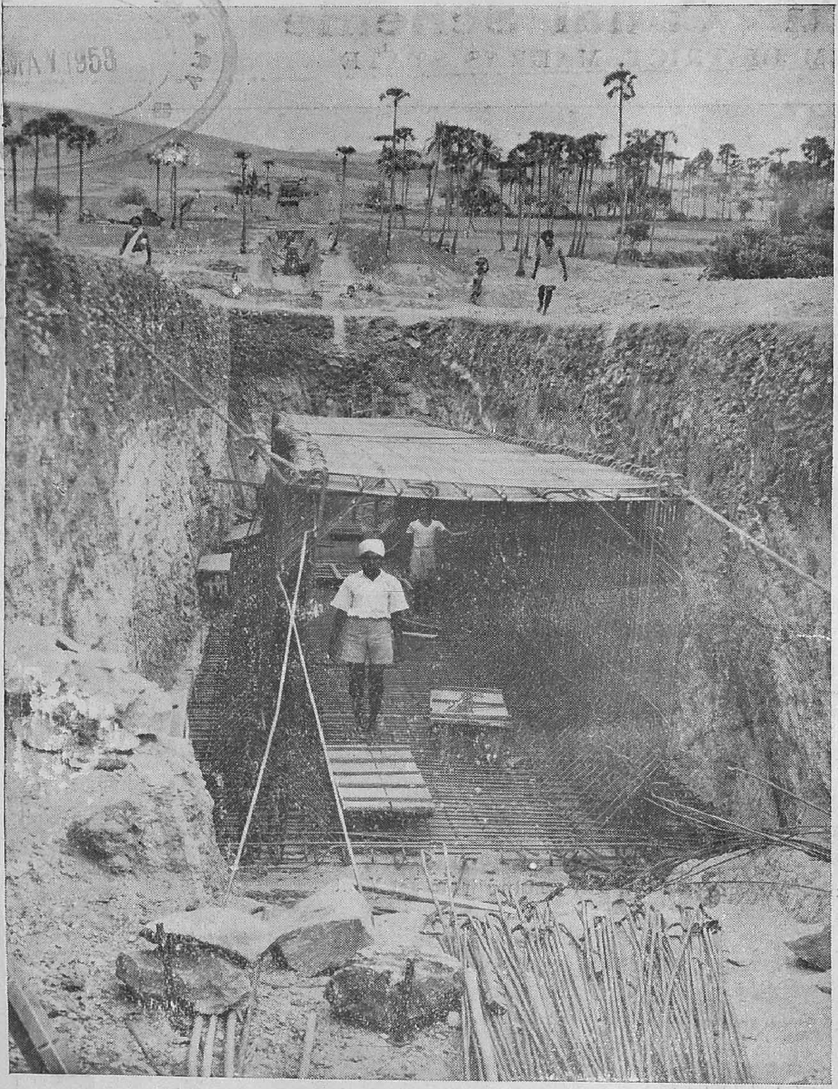


Head Sluice – Rear View – Water issuing from 1st Vent.

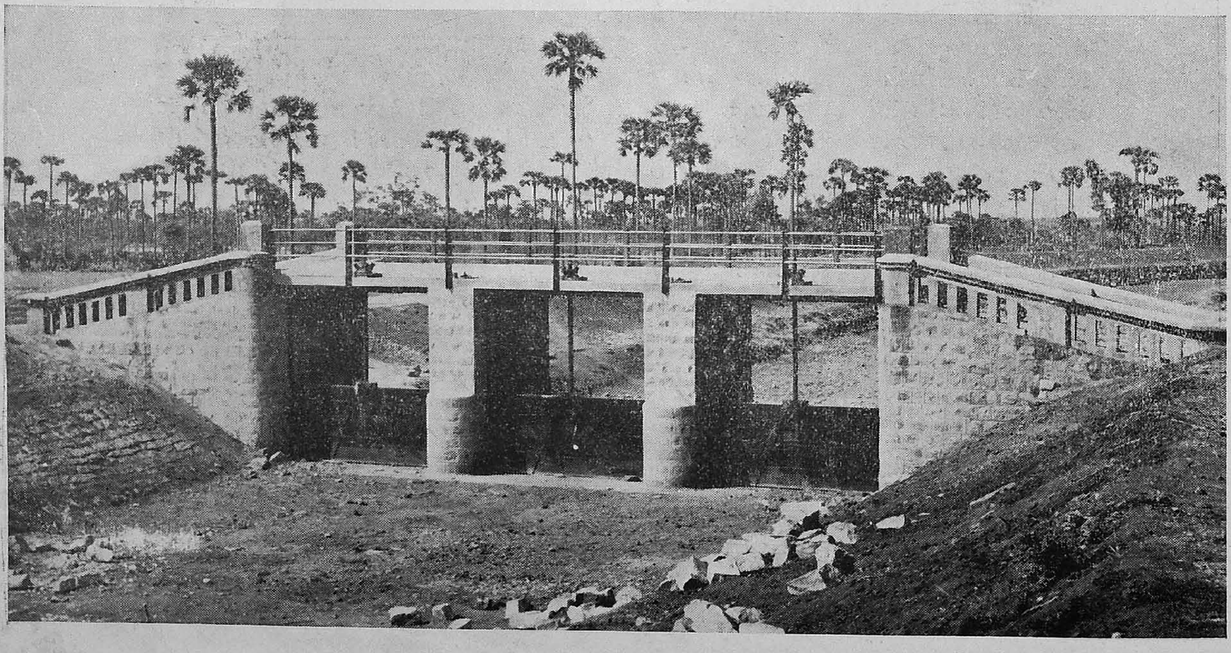
Water in front of Regulator at Ml. 19/5-510' being let down through escape at Ml. 19/5-318'

Mettur Canal Scheme

SALEM DISTRICT,
MADRAS STATE



Close up view of the Reinforcement grill tied and kept ready for concreting of R.C.C. Box between Stns. 1384 and 1457.

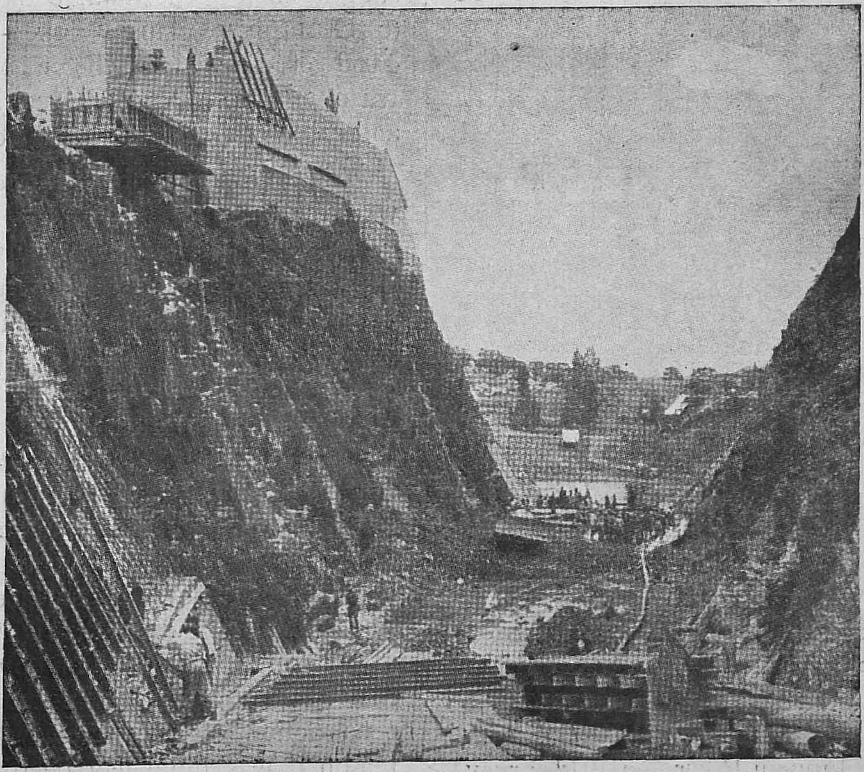


R.B. Canal - Completed Foot Bridge and Regulator at Ml. 19/5-6

The Hunyani Poort Dam.

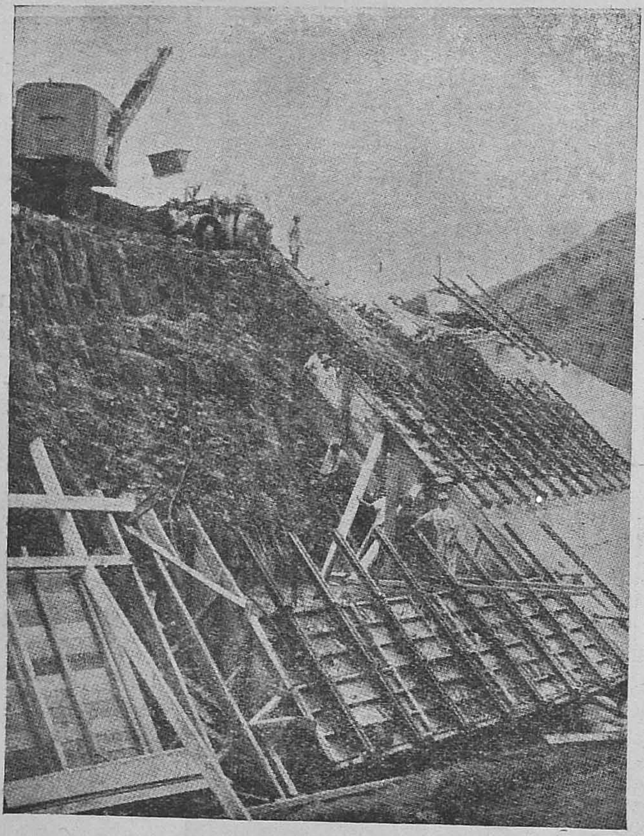
Southern Rhodesia.

Some 60 years ago, the first pioneers entered what is now Southern Rhodesia, and found fertile and wellwatered country. In those early days, the attractions were the discovery of gold and big-game hunting, and with the miners and hunters came, as an appendage, the farmers. This started the development of Southern Rhodesia. Few people seemed to think much about water in those days, and such things as soil and water conservation were unknown.



With the settlement of farmers and the few communities serving them a network of roads sprang up throughout the country, and, in view of the concentration of wet weather into one season

each year, these roads required considerable drainage to keep them passable. This enhanced the amount of water which each year found its way to the sea. As development progressed, natural springs disappeared, with the result that over the years the colony's water table dropped. With occasional bad rainy seasons, which usually ran in cycles, some areas became drought-stricken. Wells and boreholes were sunk, but these only



drained more water from the soil. People now became aware of the need for dams to build up falling resources. With the growth of industry in Rhodesia, good water supplies became even more essential.

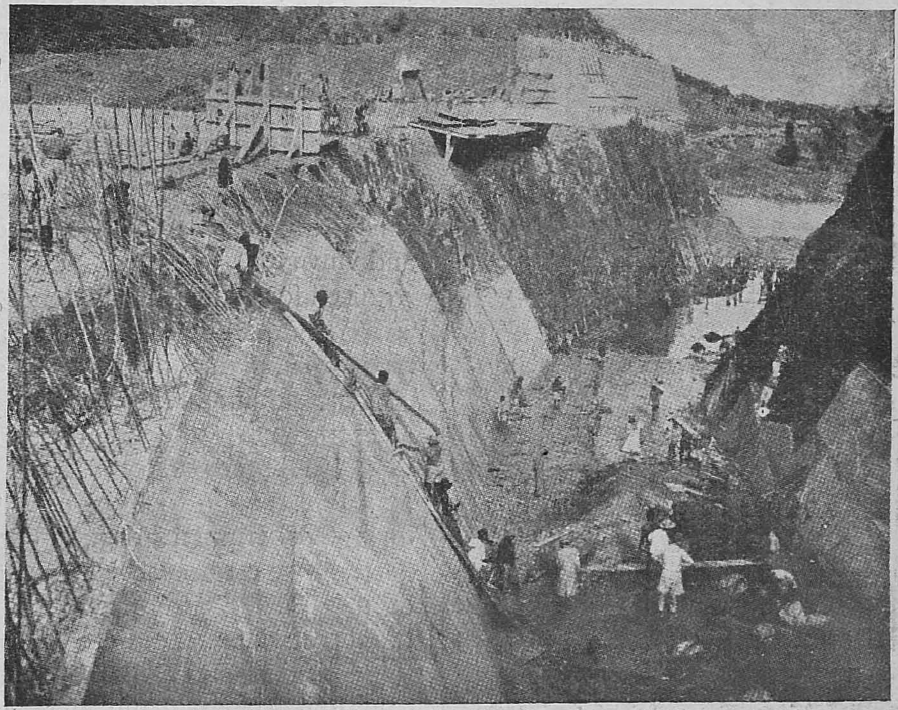
As far back as 1910, the British South Africa Company had explored the possibility of a dam in the Salisbury area and had discovered that an ideal site for a dam existed 19 miles from Salisbury on the Hunyani River. In 1942 survey figures proved that a dam could be constructed on this site which would hold back more than sufficient water for Salisbury's requirements over the next 30 years. Meantime Salisbury Municipality had engaged the services of Stewart, Sviridof and Oliver, consulting engineers, of Johannesburg, to report on favourable dam sites for the construction of a large new dam near Salisbury. In 1946, the consultants reported that the site at Hunyani Poort was the most favourable, and drew up plans for a 57 ft. dam wall of concrete which would hold back 14,000 million gallons of water.

At this point, however, the Government decided that the site was far too good to be wasted on anything but the maximum possible sized dam, and a subsequent survey proved that a 90 ft. wall would hold back 55,000 million gallons. Agreement between Salisbury Municipality and the Southern Rhodesian Government was reached whereby each should bear half the cost of constructing such a dam. The Hunyani Poort Dam, as it is now called, would serve three functions: (a) to supply ample water for Salisbury's growth, both urban and municipal areas; (b) in accordance with the Government's plan to decentralise industry, the township of Norton, six miles below the dam, could be developed; (c) Government plans for the development of a 4,000-acre irrigation scheme below the dam, where experimental stations could be established and catch crop farming achieved.

The Government thereupon commenced work on designing the dam wall, and made plans for the deviation of the main railway line between Salisbury and Bulawayo. This railway line passed over land which would be "drowned" in the event of a dam being constructed at Hunyani Poort. Experiments were conducted to discover what would be the most suitable type of wall. In 1948 it was thought that a concrete wall would be possible; however, it was found that the formation of the left-hand bank consisted of banded iron stone overlaying dolorite which lay about 15 ft. below the surface. The dolorite dipped sharply towards the right-hand bank and was fissured. Exploration by boring proved that this formation was unsatisfactory for the construction of a concrete wall and for this reason it was ultimately decided to adopt the American technique for constructing a rock fill dam wall. In 1949, David May, adviser to the American Bureau of Reclamation, visited the colony and reported on the suitability of the materials at hand for the construction of a rock

fill dam wall. A dam was designed consisting of an imprevious core and cut-off, an inner shell of previous material and an outer shell of rock fill, with an earth blanket sealing the right-hand flank and extending upstream, together with a spillway of the side channel type lined with reinforced concrete.

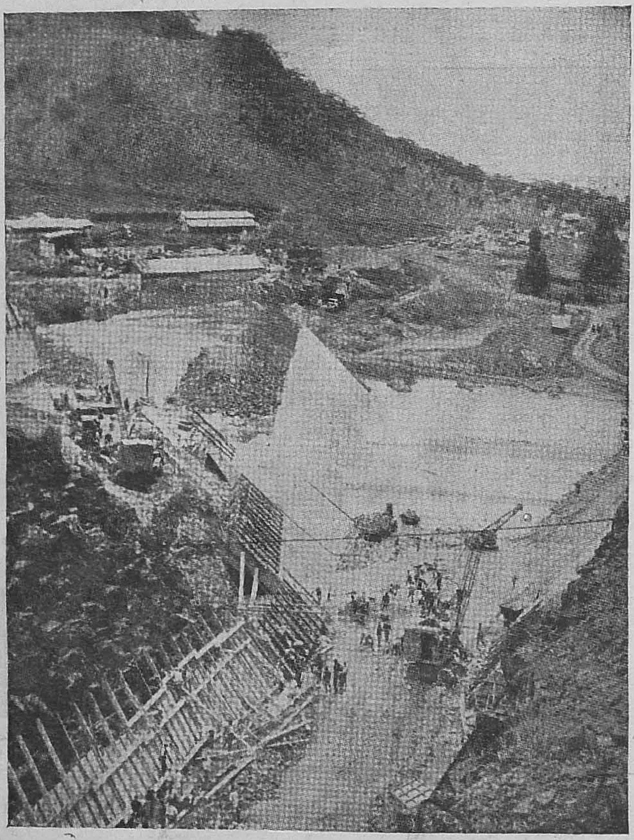
David May confirmed that the soils and materials were suitable for such a design. Tenders were then called for from contractors interested in the construction of what would be the biggest artificially-contained body of water in Capricorn Africa, and the largest earth wall, the lake formed thereby holding back 55,000 million gallons and covering an area of about 44 square miles. The contract was awarded to Richard Costain, Ltd., London, in association with Clifford Harris (Pty.), Ltd. It was stipulated that the dam should contain the 1951–52 run-off from the catchment area and work had to be sufficiently completed in time to do this. In this connection, it might be well to bear in mind the fact that for four years the rainy season in Southern Rhodesia had been very much below normal, and all experts considered that it would take at least two or even three seasons to fill the dam.



After the contract was signed an immediate start was made on the work and by mid-January, 1950, a camp had been established and plant began to arrive. Towards the end of 1950 the intake tower, valve house and the concrete conduit connecting these had been completed. Cement grouting of the core trench had been finished and work had started on filling the core with the impervious material from borrow pits upstream. In mid-December, 1950, when heavy floods occurred in the middle of the rainy season, work was held up and the core trench was flooded over. However, after four weeks hold-up, work was recommenced, and it was found that little damage had been done to the material already compacted in the core. Now began the battle which was to have a dramatic climax. From the end of the rains, 1950-51, the contractors had at most seven to eight months before the rains came again. During this time approximately one million cubic yards of materials for the core, pervious sand for the inner shell and rock fill for the outer shell had to be moved, placed in position and the centre core consolidated. At the same time, work had to go ahead on the spillway in order to make it capable

of taking flood water should the dam fill in one season. Work went ahead steady and apart from the actual concrete lining of the spillway, was complete before the rainy season started.

Then week after week it rained with no let-up, and it was obvious that Southern Rhodesia was in for a really record wet season. Work was badly hindered and the water in the dam rose rapidly. Work by day and night became imperative. Floodlights were erected and all available men and equipment were placed at the disposal of the contractors. In February, 1952, came for Southern Rhodesia a really tense two weeks.



It became apparent that the dam would fill in one season, and something approaching panic seemed to infect some of the local population. Warnings were sent out over the radio. Rhodesia Railways thought that their new bridge built below the dam was in danger, and one small boy arrived at 5 o'clock one morning as the night shift was coming off, and asked the Agent when the dam was going to burst. He had hitch-hiked from his home in Salisbury to be in on the great moment, and completely ignored the fact that he was standing immediately below the main centre of any burst that might occur! A most disappointed boy was returned to Salisbury after being given breakfast.

On Feb. 17, the flood overflowed the spillway in a most spectacular fashion, but apart from bending a few scaffold poles and taking some shuttering down the river little damage was done. Flood water continued for some weeks, but once the water had subsided sandbags were placed across the crest in order to raise the level of the water by 18 in. or so, which enabled evaporation to balance any runoff coming into the dam, and the contractors carried on with the finishing of the concreting of the spillway.

Interesting points in connection with the construction were that the intake tower conduit and valve tower were completed before the pipes required for taking the water off the dam had arrived, and all pipes, including a 40 in. diameter pipe for supplying Salisbury, had to be threaded on the conduit and into position. There are three pipes altogether, the second supplies water at a rate of 10 cusecs to riparian owners below the dam, and the third will be used to supply water for the Government irrigation scheme below the dam. In the original scheme, two bridges had been envisaged of fabricated steel, one to connect the top of the intake tower to the main line, and the second to carry the pipeline supplying the irrigation scheme and the Salisbury Municipality across the spillway. The Government considered alternatives put forward by Richard Costain, Ltd., for substituting prestressed bridges in place of the steel structures, with the result that Rhodesia will shortly have two prestressed bridges: one, the footbridge connecting the main line to the intake tower, and the other a bridge of unique design involving both a prestressed bridge and an aqueduct which uses the principle of cracklessness in prestressed concrete to make it an aqueduct of itself. Since America has just completed its fourth prestressed bridge, Rhodesia is not far behind.

An interesting point to note is the fact that at the moment evaporation from the dam is at the rate of 50 cusecs, while Salisbury's estimated consumption, will be at the rate of 10 to 14 cusces. Therefore, a bigger dam would cause unecono-

mic loss of water from evaporation. The cost of water delivered at the foot of the dam wall is approximately 1d. per 1,000 gallons.

Hunyani Poort Dam in the Robert MacIlwaine Park is now a reality, and one of the biggest assets in the country. It is the largest artificial lake in Capricorn Africa and one of the largest in the whole of South Africa. It offers ideal conditions for boating and pleasure. However, owing to crocodiles which are alleged to be numerous, bathing is not allowed, but plans are in hand for swimming baths, boat club and other amenities.

—With acknowledgments to "The British Constructional Engineer", November–December, 1952.

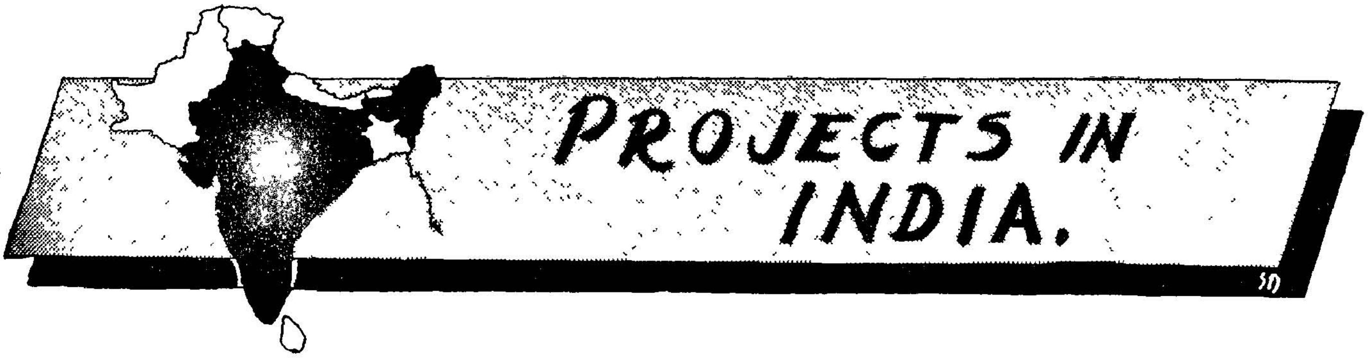
A GOOD AND CHEAP WAY TO FREE RUSTY NUTS AND BOLTS

Trying to force a dry nut off a bolt by means of oversized wrenches may easily result in twisting the bolt in two, while the grip of the rusty threads on each other is in no wise affected. Yet there is an easy way to avoid both troubles and greatly reduce the hard labour involved in dismantling the dry, rusty threads. If the worker will pre-soak the rusty threads with plain cold water, he will find that the stubborn parts will let go easily, without any damage at all. Where the location will permit, the threads should be thoroughly soaked a short time before the wrench is applied and the dismantling should proceed while the threads are wet. If the water is allowed to dry off not too much help will be noticed. If not possible to soak the threads, often a rag or a bit of waste, well wet and placed on the projecting end of a bolt, will do the trick nicely.

An old journeyman mechanic was working on a repair gang reconditioning coal-fired domestic heating furnaces. Most of the bolts encountered were stove bolts only, but their rusty threads were struck as tight as any, and often had to be chopped off with a cold chisel and hammer to get any fair speed in dismantling the furnaces. After a while, the crew noticed that the old mechanic did not seem to be having much trouble unscrewing nuts that no one else could handle. Pressed for a reason, the old man showed them a bottle of "magic formula" which seemed to loosen the rust almost miraculously. But never would the old man give up his secret, until one day when his bottle got empty some one caught him filling it at the water tap!

Remember to soak the threads in advance, but do not let them dry again before using the wrench. A day's drying will set the threads almost as tight as before.

—With acknowledgments to "Western Construction," January '53.



Kalinadi-Hydro Electric Project

(BOMBAY STATE)

History

The southern portions of the State of Bombay do not have at present any large power station to serve their growing needs of electricity. The nearest is the recently completed Mahatma Gandhi power station at the foot of the Jog Falls in the adjacent State of Mysore. The Government of Bombay had an agreement with the Mysore Government to supply 5,000 E. H. P. at the generating station bus, but as this block of power could not be economically utilised at the load centres in the Bombay State, situated over 100 miles away from the power station, the Government of Bombay had protracted negotiations with the Government of Mysore to secure a larger block of power as a result of which 11,500 kws. has been agreed to be given by the Mysore Government for distribution in this area. The load surveys conducted by the Electric Grid Department in the area show that the demand would soon exceed the supply available from the above station. Hence, there was an urgent need to look for another source of power within the Bombay State itself.

The development of the Kalinadi Basin is the most logical step to attain the above objective. The potentialities of the river were studied as far back as in 1921 by Mr. P. L. Bowers under the direction of the Hydro-Electric Surveys conducted by the Government of India. As a result of his investigations Mr. Bowers recommended a limited development of power of the order of 80,000 kw. (continuous).

The Government of Bombay ordered fresh investigations and preparation of a general comprehensive report on the full potentialities of the basin early in 1947. The investigations were immediately started and completed in 1948. The Consulting Engineers who carried out the work submitted their report in December 1948. The report indicates that Kalinadi basin will be capable of developing electric power of the order of 3,25,000 kw. continuous with an installed capacity of 5,90,000 kw. in four different power stations. This power is expected to satisfy the needs of the area for a long time.

Salient Features of the Scheme

General:—The Kalinadi river rises on the escarpment of the Western Ghats and flows in an easterly direction for about fortly miles to Bomanhalli, where it takes a south-westerly course for a further distance of 30 miles and finally it swings round in a westerly direction and enters the Arabian sea near the port of Karwar after having traversed nearly hundred miles. Thus, unlike other rivers in the plateau which maintain their course eastwards, Kalinadi river turns westwards making it possible to utilise a greater portion of the catchment area for power purposes within the Bombay State.

The main tributaries of the Kalinadi are :

(1) The Pandri, (2) The Tattihalla, and (3) The Kaneri rivers.

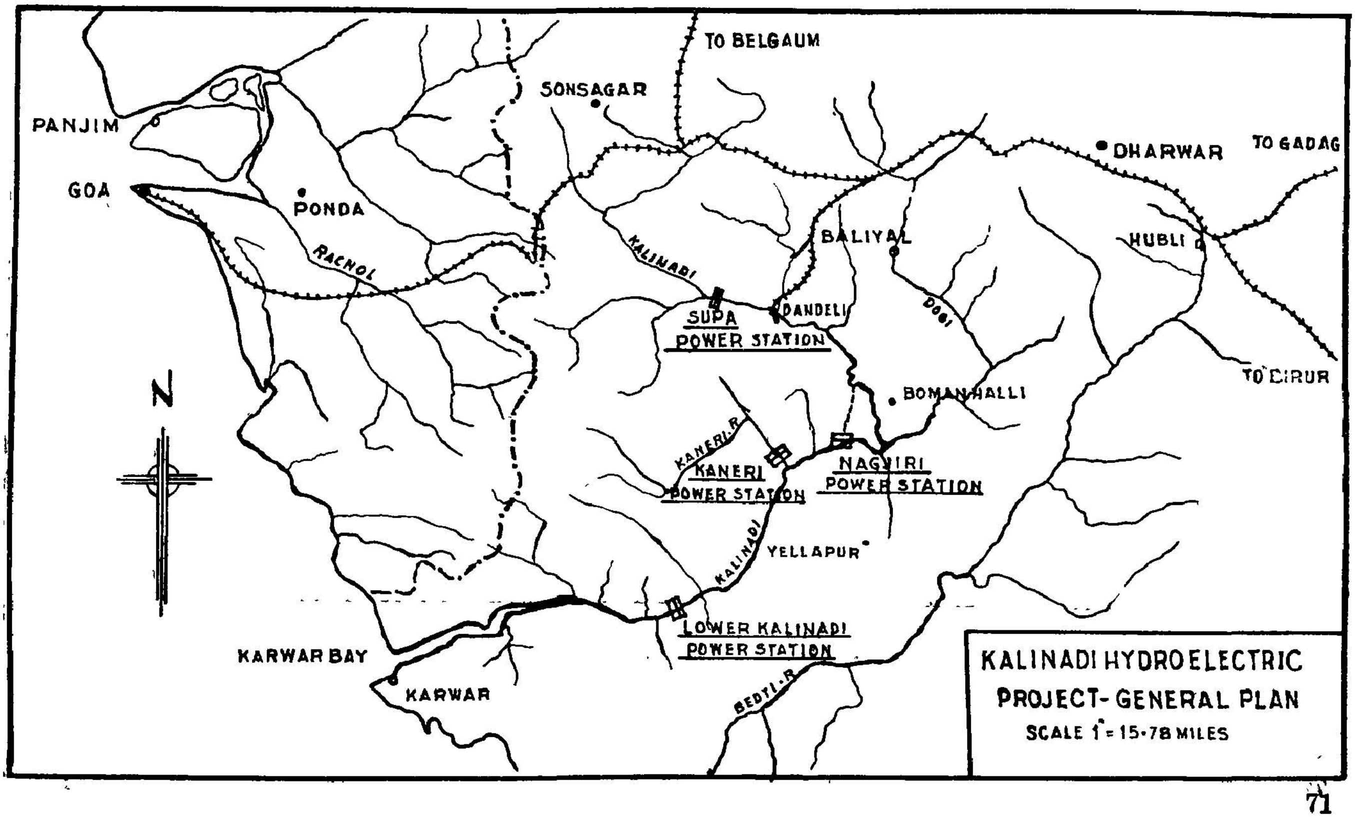
The drainage basin of the river covers a total area of about 1,870 square miles of broken

plateau deeply dissected by river courses. The area is in the region served by the south-west monsoon and the rainfall in the Ghat escarpment may reach an average of nearly 300 inches per year in some locations The average amount of rainfall decreases eastwards and at the eastern limit of the catchment becomes as low as 40 inches.

Preliminary Investigations reveal that the most advantageous development would be as follows:

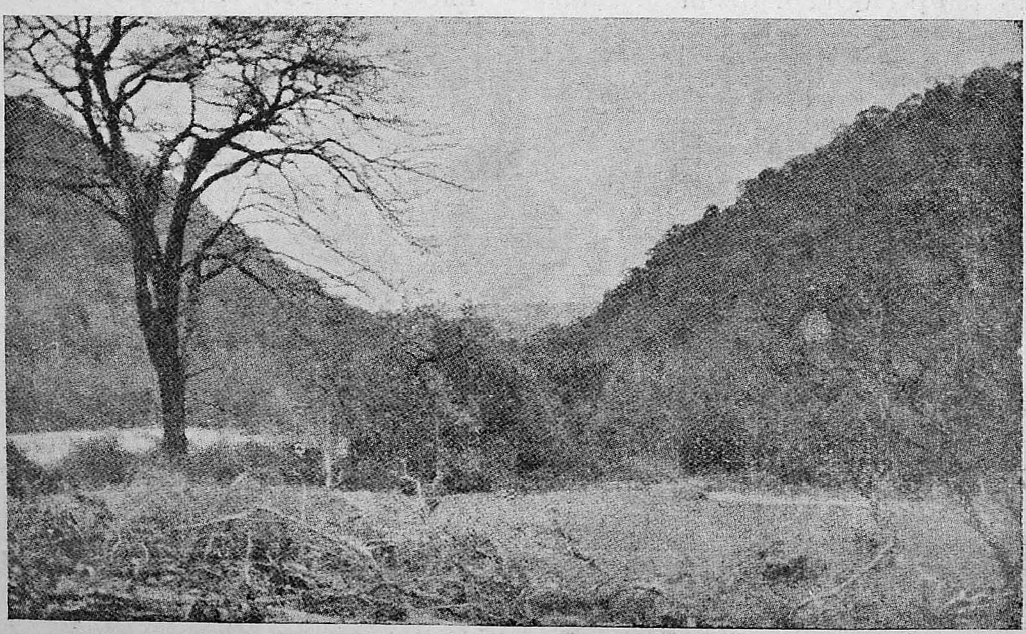
1. *Supa Dam and Power Station*: In view of the concentration of rainfall in a few months of the year, it is essential to have good storage sites for conserving the monsoon waters. A favourable site for such a reservoir is to be found in the neighbourhood of the village Supa about 1½ miles downstream of the confluence of Kalinadi and Pandri rivers where the broad valley contracts to narrow gorge permitting the economical construction of a dam about 275 ft. high, with a gross storage of 1,28,000 Mcft. The Supa Dam is the key to the whole basin development providing a controlled flow of 2,855 cusecs in an average year. When the reservoir is filled, the water spread will extend to 46 square miles. The effective storage would be 118,000 Mcft. equivalent to 130 per cent. of the mean annual run-off in an average year from the catchment area of 400 square miles. There will be a power station at the foot of the dam with an installed capacity of 90,000 kw. in three machines of 30,000 kw. each. The average annual output from this power station is expected to be about 400 million KWHrs.

2. *Nagjhiri Scheme*: Between Bomanhalli and the confluence of Nagjhiri Nalla with Kalinadi, the river makes a great loop some 15 miles in length, over the middle portion of which it drops rapidly over a series of cataracts, through a total height of 1,080 feet. By diverting the river through a tunnel and short-circuiting this loop, it would be possible to utilise this head for an economical power development. A head pond below Dandeli will be formed by the construction of a diversion weir about ¼ mile up stream of Bomanhalli. There would be a pressure tunnel about 30,000 feet long and about 21 feet in diameter from the head pond to the surge from which penstocks will be taken to a power house near the confluence of Nagjhiri Nalla with the main river. The net head available will be about 1,000 feet. The installed capacity will be 350,000 kw. in seven machines of 50,000 kw. and transmitted over long distance transmission lines to



KALINADI HYDRO ELECTRIC PROJECT-GENERAL PLAN
SCALE 1"=15.78 MILES

THE KALINADI DAM SITE AT SUPA (Close up view)



THE SUPA DAM SITE (Distant view)

industrial centres. This would be the largest station of the group and is expected to produce about 2,300 million KWHrs. in an average year.

3. *Kaneri Scheme*: This scheme will utilise the waters of Kaneri river, one of the main tributaries of Kalinadi. The river falls fairly uniformly by about 1,000 ft. in a 12 mile stretch between the dam site and power station site. The scheme includes construction of a dam of about 250 ft. in height about ½ mile upstream of Gund Causeway to impound about 7,600 Mcft., a pressure tunnel about 20,000 ft. long and equivalent diameter of 10 ft. and a short pipe line leading to a power house. The maximum head will be about 1,170 ft. The installed capacity would be 75,000 kw. in three machines of 25,000 kw. each. The energy output in an average year would be about 390 million KWHrs.

4. *Lower Kalinadi Scheme*: This would be the lowest in the chain of power stations situated on the main river and in addition to utilising the controlled discharge from Nagjhiri and Kaneri power stations, would benefit from the unregulated run off from a further 678 sq. miles of catchment area. The scheme will comprise of a dam about 205 feet high about 1¼ miles upstream of the confluence of Baginkatte and Kalinadi rivers with a power station at the foot of the dam. The installed capacity will be 75,000 kw. in three machines of 25,000 kw. each The annual output of energy in an average year would be about 500 million KWHrs.

Thus the whole basin will be capable of developing a huge block of power. When fully developed, the cost of generation is expected to be as low as 0.13 of an anna, based on ruling prices in 1948.

The scheme is capable of being developed in stages as the load develops. The first scheme to be taken up will probably be the Supa scheme which is capable of meeting a maximum firm demand of 60,000 kw. and also will provide the necessary controlled storage which is essential for the development of the main Nagjhiri scheme. Nagjhiri scheme or Kaneri scheme could follow Supa depending on the load development.

In the ultimate stage, power from all the stations will be brought to Nagjhiri bus bars over 110 KV interconnecting lines and from this station the main 220 KV lines would emerge out to load centres.

Benefits

The area will benefit from the industrial development rendered possible as a result of cheap power resources. The reservoir at Supa and the controlled discharge of the river between Supa and Bomanhalli and lower Kalinadi and Karwar will facilitate water borne transport of forest products.

Large blocks of cheap power would be available for the establishment of new Electro-Chemical and Electro-Metallurgical Industries like aluminium, ferro alloys, etc., as deposit of bauxite and manganese are to be found in close vicinity. The expansion of the present industries like textiles, and forest products will be possible. Cheap power will also be available for electrification of towns and rural areas. This will result in considerable increase in the standard of living of the people.

—Reproduced from a Booklet distributed in the International Engineering Exhibition held in Delhi (1951).

Tell Employees Their Rating

If you do not know how to tell workers how they stand on your rating system, here is what to say and how to make merit rating work.

Most employees have a merit-rating system. But not all let subordinates know where they stand as the result of merit ratings. Telling them is not easy, unless you have this plan.

Rating an employees performance is only the first step in a successful merit-rating programme. This step is merely the diagnosis. The " cure " comes when the rater sits down to tell the ratee how he rated and what he can do to improve himself. Such informal talks will:

*Give him a good understanding of how well he is doing his job and where he stands.

*Provide an open discussion on how he can correct his weaknesses and cultivate his strengths.

*Clear up any misunderstandings of what is expected of him before they reach serious proportions.

*Build a strong relationship between employer and employee.

Performance ratings should be based on facts rather than opinion or personal bias. And ratings should be open to correction when they can be proved in error. People like to know where they stand as long as the evaluation is fair, constructive, and positive.

These five steps lead to better merit-rating discussions :

1. *Plan how, when, and where to discuss.* Discussion should be held in strict privacy over a period of several days or weeks, depending on the number of people involved.

The factual information that influenced the rating should be handy. And there should be no pressure on the employee.

2. *Predetermine how the employee will react.* Co-operative, constructive employees are usually easy to talk to. They are in the majority. They present no particular problem. But employees who are skeptical, antagonistic, and destructive can be hard to handle. These are the people whose reactions should be estimated carefully.

Certain techniques can be used to soften employees who strongly deny their ratings, and who are surly and uncooperative. Likewise there are ways of getting the quiet, non-responsive employee to talk. See (5) below for possible employee reactions and suggestions for coping with them.

3. *Put the employee at ease.* The rating discussion is not a trial with a penalty. It is designed to help employees help themselves and develop into better employees.

A friendly, constructive atmosphere will set the employee at ease. When he enters the office, greet him with a friendly statement that is of interest to him and requires a reply.

After the correct atmosphere is created, get down to business. It is perfectly natural for the employee to want to know how he was rated. So tell him how the merit-rating programme works. This will inform him and also put him at ease.

4. *Explain the purpose of merit rating.* It is extremely important to be sure the employee understands the purposes of merit–rating, especially when the programme is just getting underway. The purposes of merit–rating are many. Keep the following over-all objectives clearly in mind:

*To provide periodic reviews of performance.

*To point out strengths and weaknesses so that the former can be cultivated and the latter corrected.

*To provide a fair and unbiased means of determining qualifications for promotions, transfers, demotions, rate increases.

*To recognize those who have outstanding ability and potentiality, and deserve training for higher positions.

*To weed out those who are not qualified for the type of work to be done and who cannot contribute to the productive efforts of the company.

5. *Tell the employee how he was rated.* After the employee has been put at ease and you are sure he understands merit-rating, you are ready to tell him how he was rated This is the meat of the whole discussion. It is here that you will be faced with various reactions from employees. There are certain principles and procedures that will help you meet these reactions. Fifteen of them are listed at the right.

Dealing with employees who are skeptical of the ratings is more difficult. A few may have a hostile attitude. They may get angry when you tell them they have been rated low on a certain factor. When faced with such an attitude, do not push for agreement. Try to find out why he does not agree and show a willingness to listen to his side of the story. Then follow through and keep your promises to him.

When faced with talking with the sensitive-type employee who accuses you of favouritism, it is best not to waste time denying the favouritism. It is far better to tell why you might favour the best man.

Should you discuss one employee's rating with another employee? It is difficult to give a definite "Yes" or "No" answer. However, generally it is not smart to allow yourself to be drawn into comparisons with other workers. Keep the conversation confined to the man you are talking to.

The important thing is to be positive and objective in your discussion. If you can show that your ratings are fair and based on actual happenings, talking ratings with employees will be much easier.

With acknowledgments to "McGraw-Hill Digest," November, 1952.

HOW TO MEET AN EMPLOYEE'S REACTIONS IN HIS RATING ?

1. Sandwich unfavorable remarks between favorable remarks. Compliment the employee at the beginning and end of the discussion.

2. Emphasize the reason why the rating was given. Cite specific instances of performance. They are then more acceptable to the employee.

3. Allow the employee to express his reactions to the ratings. He should state what obstacles might stand in the way of his doing a good job.

4. Do not show anger or hostility, regardless of the remarks the employee may make.

5. Do not be too anxious to prove him wrong. Help him save face and leave his self-respect intact.

6. Take plenty of time.

7. Do not expect to convince him of anything while he is angry.

8. If he wants to talk, do not interrupt.

9. Do not be vague about personality shortcomings.

10. Show a sincere interest in the employee's work and his problems.

11. Be sure criticism is positive.

12. Let him know you are willing to change a rating, but only when he has facts to substantiate such a change.

13. Be sure he knows what you expect of him.

14. Do not hesitate to recognize the employee who is rated high.

15. Leave his self-respect intact.

Grand Anicut Across Cauvery

The Grand Anicut is an ancient structure at the Head of the Tanjore District. It was constructed by the Chola Kings to divert water which was wasted through Ullar into the Coleroon, to the Cauvery river and its tributary, the Vennar. It is credited with having been constructed round about 200 B. C. when a famous Chola King, Karikala Chola, ruled the south.

2. *The Cauvery River*:—The river Cauvery, considered to be the 2nd sacred river in India next only to the Ganga in North India, rises in the Eastern slopes of the Western Ghats near Mercara (Thalaikaveri) at an elevation of 4000′. After passing through Coorg territory for about 60 miles, it flows for a considerable distance over the Mysore Plateau (vide Fig. 1). The river receives 3 tributaries in Mysore State, two of them called the Hemavathi and the Lakshmanathirtha are upstream of the present large storage reservoir called the "Krishnarajasagara" built by Mysore Government, and a third the Kabini which drains the Manantody hill. The Cauvery has a high fall at Sivasamudram of over 400 ft. Here it divides into two branches and flows over the Ganganachukki and Berachukki falls. After a flow for some three miles, it is joined by the Shimsha and debouches into the plain of Madras at Hoganekal where it drops with a fall of 80 feet. Krishnarajasagara in Mysore is the first reservoir on the river and the second is at Mettur, some 54 miles below Hoganekal. About 24 miles below Mettur reservoir, the river receives another important tributary called the Bhavani, and two others Noyil and the Amaravathi join some 40 and 68 miles further below. Below the junction of the Amaravathi, the river has a shallow sandy bed and a width of about 7 furlongs in Tiruchirapalli District limits, and is here called the 'Akhanda Cauvery'. About 10 miles west of Tiruchirapalli, the river bifurcates, the left side or northern arm is called the Coleroon, while the southern arm retains the name of Cauvery. For a length of about 20 miles below the bifurcation, the two rivers run almost parallel to each other enclosing the Srirangam Island—with the temples of Sri Ranganatha and Tiruvanaikaval (Jambukeswaram). At about 10 miles to the

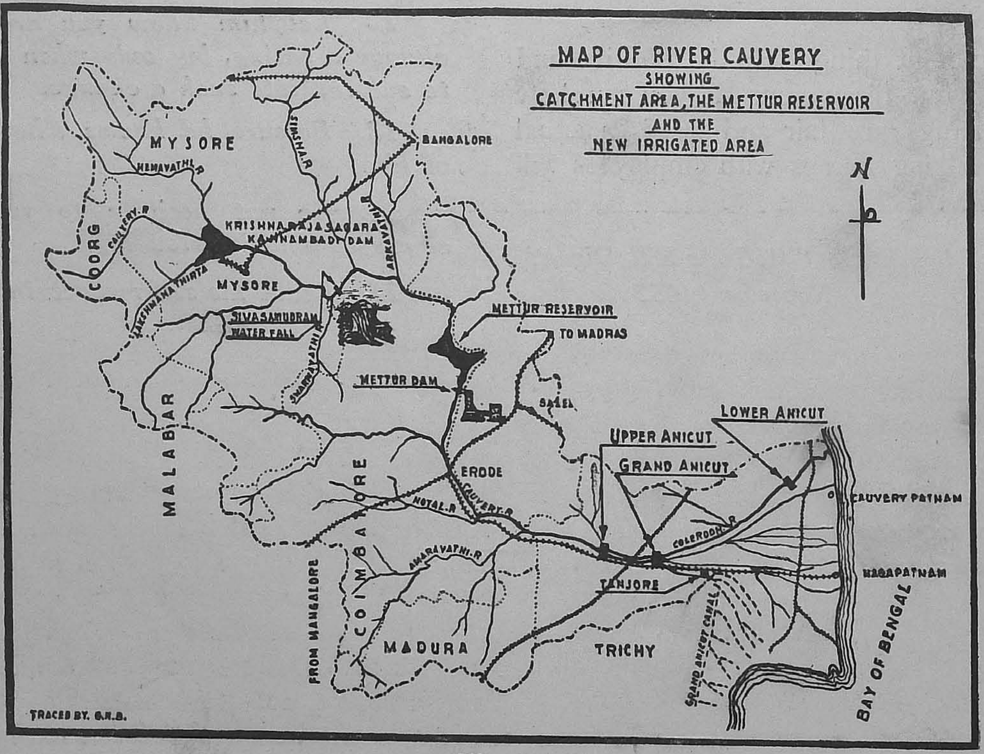


Fig. 1

east of Tiruchirapalli the two arms again join each other, the link channel being called the Ullar River. The tract of land between the two rivers from the bifurcation upto the Ullar channel is called the "Srirangam Island." Beyond this point, at the lower extremity of the island, the Coleroon takes a north-easterly course till it empties into the Bay of Bengal, forming the northern boundary of the Tanjore delta and District (vide Fig. 2). The Grand Anicut of the Cholas was built across the Ullar, to keep the waters of the Cauvery from draining back into the low level arm, the Coleroon, and to spill the surplus above the requisite depth into that arm, *i.e.*, to secure the depth required in Cauvery. The Cauvery, divides itself into many branches and after a length of about 100 miles, it reduces itself into a very small stream, a few yards wide where it meets the Bay of Bengal at Kaveripatnam. The first Engineering problem that had to be tackled was to prevent the waters draining away through the low level arm, the Coleroon, and the diversion of the requisite supply into the main arm without flooding, and also disposing off high floods without damage to the Delta. The works at the Upper Anicut are, first a barrage across the Coleroon with lift gates, the second a bed dam across the Cauvery to prevent bed scour and the third a surplus called the 150 yards calingulah a few miles below to function as a spill channel to take off a portion of the surplus water into the Coleroon below the Upper Anicut.

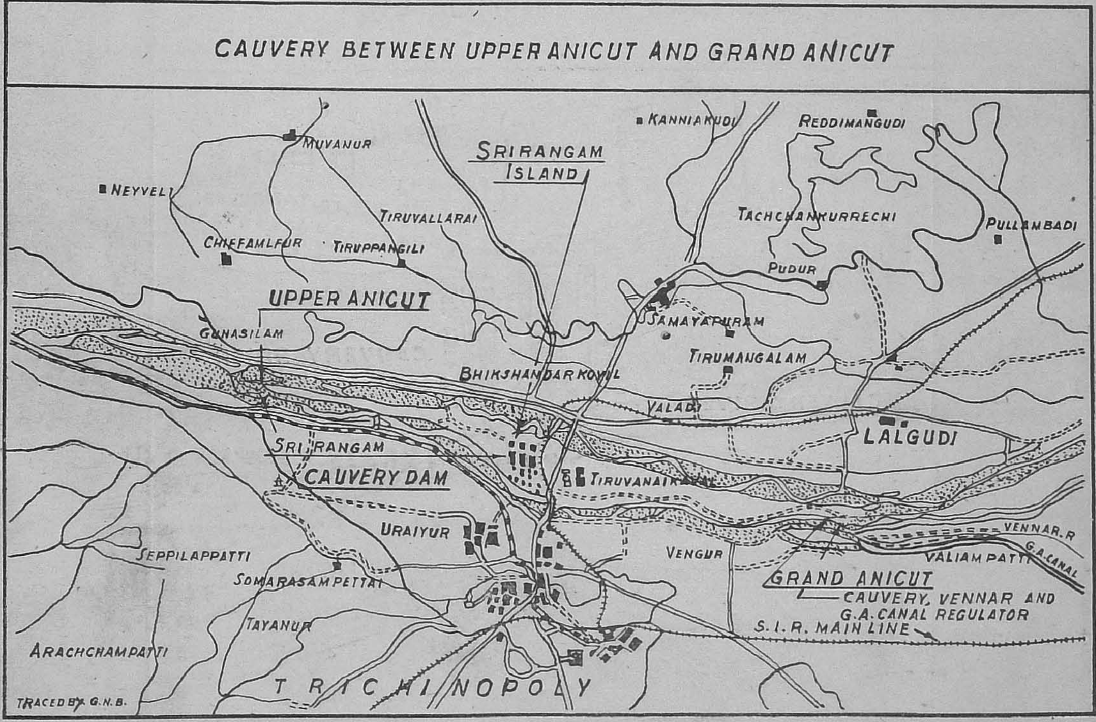


Fig. 2

3. *Genesis of Grand Anicut*:—It was then found that much of the Cauvery water was carried off into the Coleroon through the Ullar channel, at the downstream end of the Srirangam Island, mentioned in the previous para, as its bed was considerably lower than that of the Cauvery. This difficulty was surmounted by the Chola Kings (dating back to about 200 B. C.) by

building the Grand Anicut on the left bank of the Cauvery at the head of Ullar channel, (vide Fig 3). At first, it consisted of a solid mass of roughstone in clay 1080 ft. in length 40 to 60 ft. in breadth, and 15 to 18 ft. in height, stretching across the outlet (Ullar Channel) in a serpantine fashion. Owing to the disturbed condition of the country, the works had greatly deteriorated and the Delta of the Tanjore was threatened with famine. The British who succeeded to the title of Tanjore Mahratta Rajahs not of uniform section or shape. They mostly consist of a Rock fill body with an upstream impervious skin or a Rock fill core covered over with masonry against leakage. A portion of the crest was built in Ogee form, while the rest was constructed in a series of steps, the foot of the solid dam being protected by a rough stone apron. As the river Cauvery had silted up badly, in 1830, 10 small scouring sluices, 3 ft. wide and 4 ft. high, with sills at 179.6 were built, the crest of the dam being at 188.92 or a little over 9 ft.

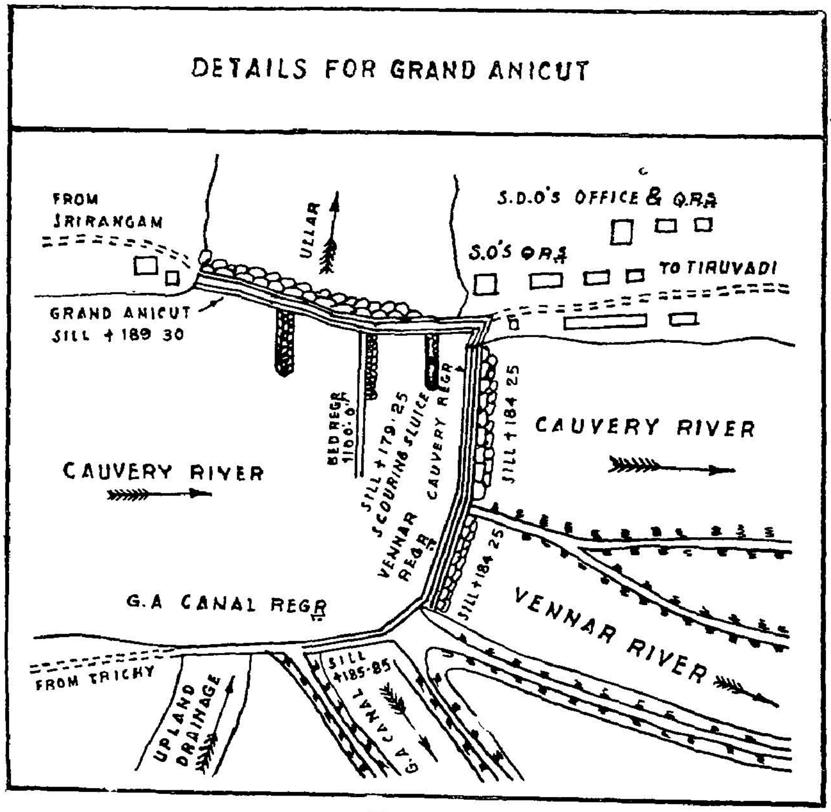


Fig. 3

in 1801, took the works in hand in 1806 and restored them. In 1839, a bridge to carry a road way was also provided over the anicut and the scouring sluices were added utilising the old anicut as foundations. The anicut is 1080 ft. in length. The construction of this old work is interesting. For, on examination, it has been found to consist of a core of roughly hewn granite, set in mud covered with outer facing of concrete 6" to 1 ft. thick all in lime mortar, but possibly mixed with natural chemicals to secure rapid setting and strength. Like most irrigation works to be found in Southern India, the anicut was higher than that of the scouring sluice. Dam stones were constructed on the top of the Dam, projecting 2¼ feet above the crest and a surplus was perhaps built at Kovilady and a scouring sluice some 30 miles below.

By the construction of the Bridge piers, and the dam stones, the effective length of the dam was reduced to 735 ft. In 1886, the dam stones were removed and automatic falling shutters 2'-10" high were fitted on the Crest. 4 were fitted in each bay of the bridge for 27½ bays, the bridge consisting of 30 spans of 32 ft. each. The

remaining $2\frac{1}{2}$ bays were occupied by the scouring sluices.

Thirteen years later, in 1899, the falling shutters were removed and replaced by lift shutters of 32 ft. span and 5 ft. high designed by Colonel Smarts and fabricated in Madras Workshops. In 1909 floods, three arches were washed away in the scouring sluice portion. These were restored omitting the scouring sluices (vide Fig. 5).

4. Though the construction of the Grand Anicut stopped the Cauvery water from running into the Coleroon, it resulted in the gradual silting up of the Cauvery bed and scouring of bed in the Coleroon. Periodical lowering the bed in the Cauvery and forming of costly embankments at the head of Coleroon in the Western end of the Island was attempted for a period of about 25 years, but this had not the desired effect. It was found that the water supply to the delta continued to diminish and the extent of land under cultivation began to decrease. In 1836—38 Sir Arthur Cotton constructed the Grand Work, at the head of the Coleroon, known as the "Upper Anicut" which was designed to prevent too much water flowing down the Coleroon and to pass adequate water into the Cauvery. This new anicut consisted of a solid brick and cutstone dam with scouring sluices at intervals. As an effect of the construction of the anicut, it was found that too much water was forced down the Cauvery and the bed of the river at the place got deep during heavy floods. To check this, a dam, of the Grade wall type now known as the "Cauvery Dam," was built

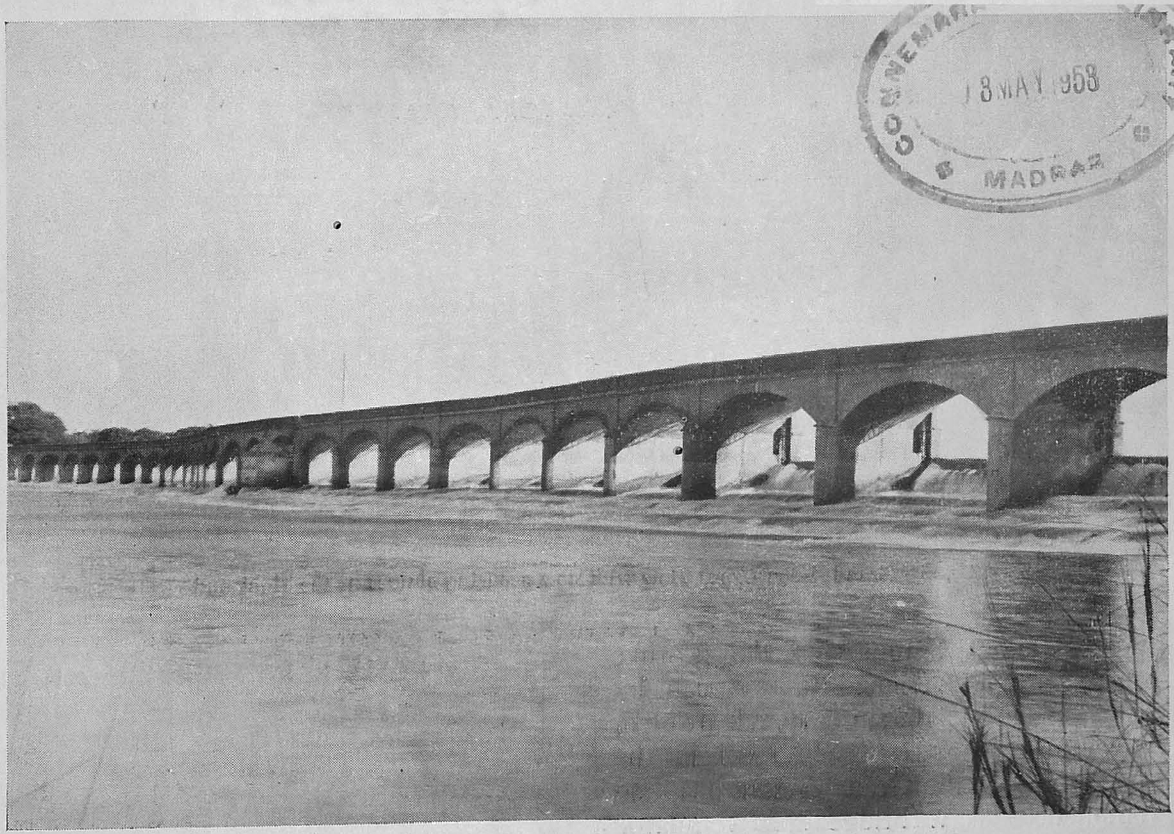

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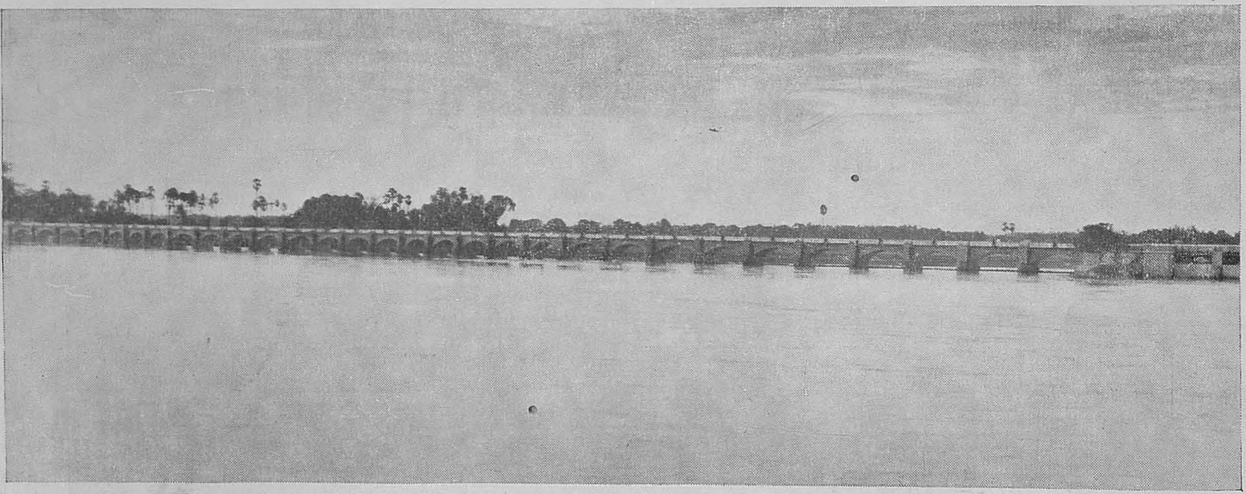
Fig. 4—Grand Anicut Rear View

across the Cauvery in 1845 (vide in Fig. 6.) Even after construction of these works the difficulty of the distribution of the flood waters between the two rivers still existed for many years. Between the years 1899 and 1904, the Upper anicut was entirely remodelled and reconstructed as a combined bridge and regulator with 55 spans of 40 ft. each fitted with Col. Smarts' counter balanced lift shutters, at a cost of about Rs. 6½ lakhs. The name of Sri Rajagopala Iyengar is associated with this. Each shutter weighs about 8 tons, but the gearing arrangements are so designed that it can be operated by one man. The shutters, when down, will hold water up to full supply level in the Cauvery. Similarly, the Grand Anicut has also been remodelled as a bridge cum regulator with lift shutters and is functioning both as an anicut and a surplus work. Between the Cauvery dam and the Grand Anicut, three surplus works, viz., 150 yards Calingulah, Vaduvagudi and Perumal Koil surplus sluices have been constructed to divert all surplus water into the Coleroon during floods. When the supply exceeds the requirements of the delta channels, (now the Cauvery, Vennar and the Grand Anicut Canal) the gates on the Grand Anicut are raised and the surplus is passed down into the Coleroon whence it proceeds down to the Lower Anicut (vide Fig. 7). There, it is again regulated and utilized for irrigation by means of other canals with which we are not here concerned.

5. Immediately below the Grand Anicut, the main river divides into two principal branches, (*i.e.*) the Cauvery and the Vennar. This forms the main switch of the Cauvery Delta proper. Previously however, the Vennar had its offtake about 4 miles upstream of the present head where a head sluice was built in 1851. In 1856 the head was shifted to the present site just below the Grand Anicut and almost in line with the Cauvery regulator and a new connecting channel was also excavated. The first few miles



Fig, 5—Grand Anicut-Front View with new scouring sluices at the right end

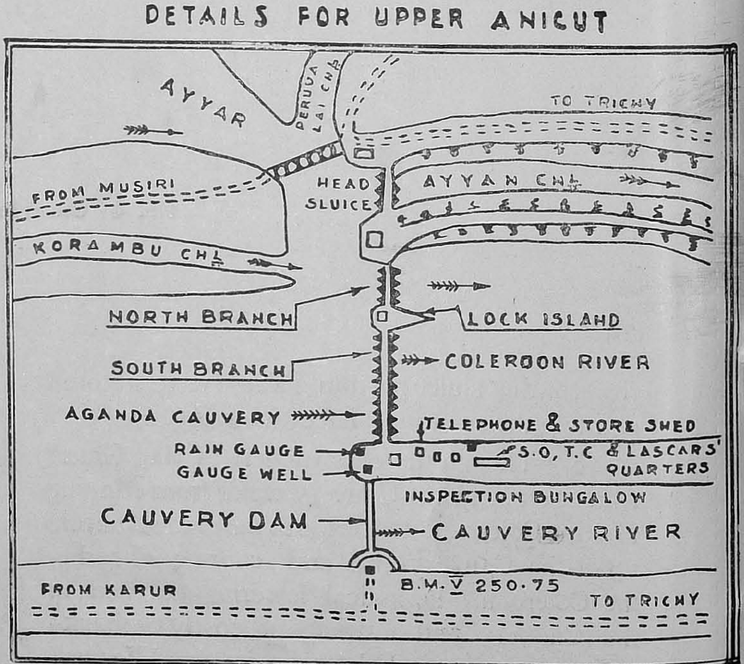


Fig. 6.

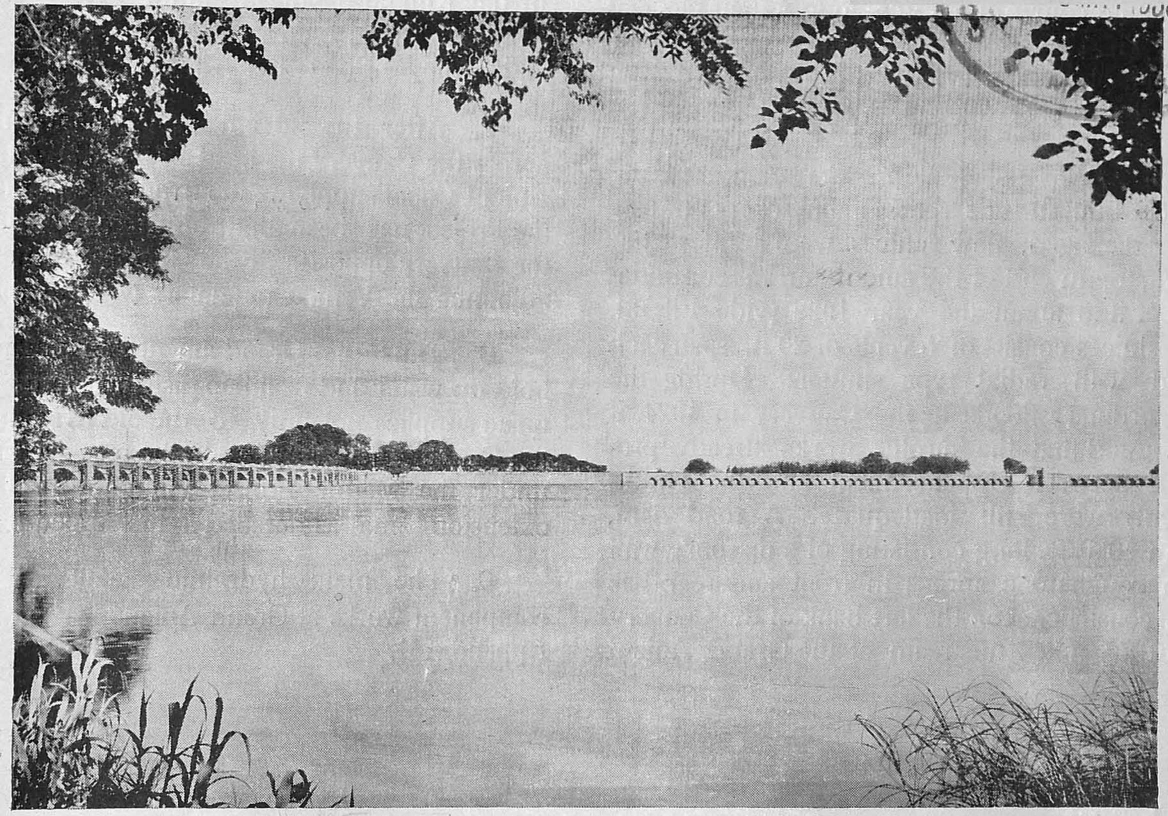


Fig. 7—The Grand Anicut – The Cauvery & Vennar Regulators Front View

Fig. 8 – Cauvery-Vennar Regulators—Front View

of the old course of the Vennar was then blocked up. The regulators for the Cauvery and Vennar at the place are fitted with ordinary screw geared shutters (vide Fig. 8).

6. *Latter improvements* :—The old scouring sluices built in the Grand Anicut proper having been damaged, new sluices were built at the downstream end of the anicut and in continuation of it in about the year 1922 (vide Fig. 8). The sluices consist of 5 vents of 20 ft. span each fitted with radial type shutters. During the extraordinary floods in the Cauvery in 1924, it was found that the surplus works already provided (between Upper Anicut and the Grand Anicut) were still inadequate. A road dam, about 4060 ft. long consisting of a masonry wall with roughstone aprons in front and rear has been constructed on the left bank of the Cauvery about 1½ miles upstream of the Grand Anicut in the Kilikudu village limits. This surplus work is intended to function only in a very extraordinary flood of 1924 magnitude.

7. After the advent of the Mettur Dam across the Cauvery the head of the New Grand Anicut Canal supplying the irrigated area under the Project has been built on the right bank of the Cauvery opposite to the Grand Anicut and adjoining the Vennar regulators (vide Fig. 9.)

8. Thus the Grand anicut is intended to hold up water and fecilitate distribution of adequate supplies not only to the old irrigation of the Cauvery delta but also to the new irrigation under the Mettur Project including Vadavar extension Canal as detailed in the Appendix I.

9. The main hydraulic details of the component works at Grand Anicut are shown in Appendix II.

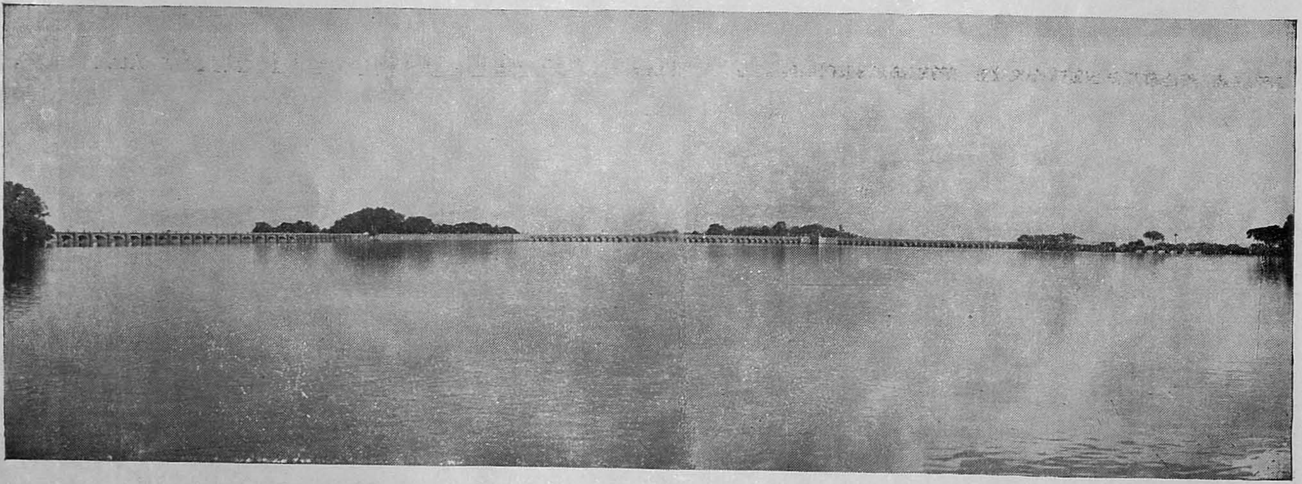


Fig. 9—Panoramic View of the Grand Anicut, Cauvery, Vennar Regulators and the Grand Anicut Canal Head Sluice

APPENDIX–I

Details of Irrigation below Grand Anicut.

Old Delta.		*(Ultimate) New area (Including Vadavar extensions).*	
Single crop	8,86,000 acres	Single crop ..	1,96,000 acres
Double crop existing ..	95,000 acres	Double crop .	1 05,000 acres
Present single crop coming under double crop newly .	70,000 acres		
Total .	10,51,000 acres	..	3,01,000 acres

APPENDIX–II

The Hydraulic details of the Component works at Grand Anicut

No. (1)	Hydraulic details. (2)	Grand Anicut. (3)	Scouring Sluice. (4)	Cauvery Regulator. (5)	Vennar Regulator. (6)	Grand Anicut Canal Head Sluice. (7)	Remarks. (8)
1	Ayacut existing acres about			4,75,000	4,16,000	1,96,000	
2	Discharge Registered in cusecs.			13,016	10,999	4,007	
3	No. of spans	30	5	42	33	6	
4	Dimensions of vent	32 span each	20′×10′	10′×9′	10′×11′—4″	30′×5′—3″	
5	Sill level	189·30	179.25	184.25	184.25	185.86	
6	Top of shutters when down	194.36					
7	Bottom of shutter when fully raised		189.25			190.19	
8	F. S. L. in front	189.05	189.05	189.05	189 05	189.05	
9	Nature of shutters and arrangements	Smarts patent shutters	Radial type gates	* Ordinary lift screw geared shutters	* Ordinary lift screw geared shutters	Radial Steel shutters hand operated	
10	Zero value of gauges	North 184.25 Front (crest) 189 30 Rear 179.25	Front 179.25 Rear 179.25	Front 184.25 Rear 184.25	Front 184.25 Rear 184.25	Front 184.19 Rear 184.19	

* These are proposed to be replaced by free roller lift shutters.

NEWS ROUND-UP

Opening of Coringa Island Project

By His Excellency Shri SRI PRAKASA, *Governor of Madras.*

The completed Coringa Island Project, about 14 miles from Kakinada was opened by His Excellency, Shri Sri Prakasa on Sunday, the 22nd March, 1953. Sri T. S. Venkataraman. Chief Engineer (General), P. W. D., explaining the potentialities of the Project said:

" We have met here to-day to celebrate the opening of a new Irrigation Canal which has been constructed under the Grow More Food Scheme of the Government.

During the last three to five years, more than 300 works of this kind have been sanctioned and taken up for execution under this scheme. Most of them have been completed and brought into beneficial use.

This scheme has some noteworthy features about it. It is an extension and, by no means an insignificant extension, to the Godavari anicut system which is a masterpiece of Engineering skill of that great and wonderful man Sir Arthur Cotton. Whatever might be the opinion held of the importance of Engineers to-day, there can be no doubt whatsoever about the supreme importance of the works carried out by him in Godavari and Krishna. Such have been the potentialities of his great work that even after 100 years of development, we have been able to extend one of his canals so as to secure irrigation facilities for an additional area of 10,000 acres. To me and the Engineers working under me, it is indeed a matter of pride that we have been able to add on to the great monumental work of his.

One of the chief items of work in this scheme is the syphon carrying the canal under the Coringa river, near which we are gathered to-day. It involved excavations of foundations down to 16′ below sea level and in a soil which is no better than liquid mud. The work therefore had some speculative features and in order to get over these uncertainties, the contractors who tendered for the work, demanded rates much in excess of the estimates. I had therefore to ask the Superintending Engineer to carry out the work departmentally. This difficult piece of work has now been completed and at a cost not exceeding the estimate.

This is a time when the level in the river begins to come down rapidly and we generally think of closing the canals for the summer. Though this new canal is to be declared open to-day, it would be possible only to send down a token supply. It will come into full operation when freshes are received in the river in June or July next. It is now my pleasant duty to request

our respected Governor, Shri Sri Prakasa, to declare this channel open and bless the successful operation of the scheme."

His Excellency, Shri Sri Prakasa opening the completed Project for beneficial use said :

* * *

" At last so late as 1950 and 1951 the Project was taken up seriously in hand. And you see the results before your eyes. A little glance on the landscape will show us the difference between the agricultural conditions on the farther side of this river and on this; while you see vast stretches of lovely green and what is called the second paddy crop on the other side, on this we have only barren fields; and I have no doubt that after this has been declared open to-day you will find the fields on this side as green as on that. On an occasion like this, it is our duty, as it is also our pleasure, to offer our grateful tribute to the work of the great Engineers that make such prosperity possible. And I should like to join my friend Mr. Venkataraman who has just spoken to you, in paying my tribute both to the memory and the work of Sir Arthur Cotton. Now that the British are no more the rulers of our land, it is but right that we should remember with gratitude what they have done and what they have left behind. It is a remarkable thing what change, freedom can bring to the psychology of the people. On this platform Mr. Venkataraman who so faithfully and so honourably served the Government through long years of patient endeavour and I who fought with Government, unite together in order to pay tribute to those who have gone before. The other day at the Cauvery anicut in Trichy, to-day on this anicut of a branch of the Godavari, we remember the same great name of S. A. Cotton. And it is also something for thinking about that the very places at which modern Engineers have worked have been places where Engineers of old had also worked. And lay public can never be sufficiently grateful for the very great work that Engineers have done through the ages. At the Cauvery anicut I was told that as far back as the 1st Century A. D. that Chola king had built the old dam that continued to exist till the 19th Century, when S. A. Cotton came to improve it. And here also the canal had been drawn by the previous Engineers to the other side of the salt river. This work stopped when they came to the curious phenomina of a salt river Salt rivers, I believe, are an anomoly. We know of the sea being salt and we think of rivers being sweet. And when we hear of a salt river we naturally feel surprised. We began to wonder if God has made a mistake. But though the older Engineers were stopped in their good work by a salt river which seems to have frightened them, our present Engineers have overcome it by going underground. And they have given us four solid syphons through which sweet water from across will come to this side, untouched by the salt water that flows above. The Engineers really are in a class by themselves. They seem to defy nature wherever they go, and the layman like myself is struck down by their achievements We, politicians particularly have had a grouse against the Engineers because they appear to spend too much money. You will remember that the great Chief Minister of the State—the united State of Madras —declared that the P. W. D. was enemy No. 2. But when you find that at a cost of about 18 lakhs and a half of rupees, you have been able to irrigate so many acres of land, while 5,000 acres of land are promising a further yield of 4000 tons of rice, I think you will agree that in the aggregate the cost is not too much. In the address they have worked out the figures and they assure that only Rs. 233 per acre is the average cost. I am going to attempt on the basis of these figures, to induce the Chief Minister to change his views and regard the Engineer even under the cover of the threatening initials of P.W.D. as his friend No. 1. And before the new Chief Minister of a separate state of Andhra takes his office, I am going to beg him to think of the Engineer on the same terms.

I have had a great deal to do with Engineers as the Minister at the Centre for Natural Resources for a whole year. During those days I had opportunities of seeing many works at many places in the land that the Engineers were going to bring prosperity to the people, and think of the dangers they face in doing their work. Only the other day at the Krishna anicut four great Engineers with four other useful assistants lost their lives. We, as we irrigate our fields and make them yield more than they did before, may forget that there are Engineers working in forests

and in mountains making the waters that we use possible. I have known of solitary bungalows of engineers on forsaken banks of canals where they stand on their post of duty undeterred either by the mosquitoes or the tiger. And to the Engineers of Madras,—in which I include Andhra, so that there be no misunderstanding—we have reason to be particularly grateful. It is a known fact that the Madras Engineers have combined efficiency with economy. And as I know from personal experience at Delhi, Engineers of other states are nervous of getting Engineers from Madras, lest they do better work at cheaper rates. You have no doubt reason to be proud of the great work of Engineers. "From the 1st Century A. D. when the Cholas were in power along the centuries of the Pallavas and the latter Cholas to the time of the Vizianagaram Kings and British, you have a great succession of Engineers. And I am not surprised. Nature is very unkind to the State. Our rainfall is very erratic. While in the north from where I come, we are almost sure of rains in particular seasons, here we have no such certainity. And the 4 districts of the important portion of Andhra, namely Rayalaseema, are in the grip of drought for every year. Nothing can overcome this difficulty except man's efforts to harness the waters of perennial rivers and bring them through dams and canals to irrigate fields that are barren. And it is no wonder that in the five year plan of the Government of India, the river valley projects have such high priority.

* * *

It gives me great joy, no doubt, as I am sure it gives you all also, to be present this month at this delightful spot. And the addition of this new and beneficient canal will greatly add both to the beauty and the utility of the countryside."

Appreciation.

The Chief Engineer for Irrigation notes with pleasure that Sri T. P. Kuttiammu and Sri N. S. Ananthanarayanan, Executive Engineers, have sent articles for publication in the New Irrigation Era. These articles will be published in the journal in due course. The Chief Engineer eagerly expects the other Officers of the Department to follow suit very soon.

QUOTABLE QUOTES

Automatic Control of Irrigation System

(For figures please vide cover page 3)

Introduction

In order to appreciate the necessity for automatic control of irrigation water supplies, let us first consider the working of an ordinary, non-automatic system.

Assume that all gates in the network are regulated to give the various discharges required. An accident or some other cause obliges a farmer to shut a gate somewhere in the system: what is the result? Theoretically, all gates upstream of his particular offtake (right up to the reservoir) would have to be manipulated in order to restore the original waterlevels (and therefore discharges) throughout the part of the system affected. If this is not done—and it can never be done exactly—there will be changes in water-levels and discharges throughout the entire scheme.

Result:—**Necessity for large canal free-boards;**

Irregular discharges to individual holdings;

Continuous need for a large staff of Overseers to supervise distribution.

Basic Equipment for Automatic Working

As constructed by Neyrpic, these devices are three in number:

I—The quantity of water delivered to each farm, and sometimes to each lateral, is regulated by what is termed, in English as in French, a "module". This delivers a known flow (according to the setting) to the farmer; the design is such that the flow remains constant even should the upstream supply level vary within certain limits, and is quite independent of downstream conditions. The gates can moreover be shut by the farmer himself should an accident, etc., make this necessary; the modules which he can draw on for his supply of water are of course opened up initially by a supervisor.

Other modules, such as the well-known Gibb type in India, exist; it would be extremely interesting to make a comaparative study of the various designs.

II-Constant upstream level gates (see fig. 2)

This is a float buoyed sector gate with counterweight attached. If the level immediately upstream of the gate rises, the float acts to raise the gate and the level falls to its previous value. It is worthwhile noting that a lip is often added to the top of the gate to give extra buoyancy if need be; in this way, pieces of wood etc., cannot block the gate indefinitely.

III—Constant downstream level gates (see figs. 3 and 4)

The float is this time contained in a stilling box which communicates with the water-level downstream from the gate. Should this level rise, the gate partially closes so that the original level is restored.

In general it can be said that, while extremely simple and robust in construction, these devices represent the fruits of much experimentation, and that they have withstood successfully the test of long service in France, French North Africa, Portugal and elsewhere.

Now for their use:

Automatic Irrigation with Upstream Control

Downstream from each farmer's offtake is placed a constant U/S level gate; the level in front of his module is thus maintained constant.

At the upstream end of each lateral is placed a constant D/S level gate with the object of eliminating the effects of differences of main canal level on a battery of large modules placed just D/S of this gate (fig 4). In this way any desired total discharge can be diverted into the lateral, *independently* of the level in the main canal and *independently* of the level downstream in the lateral.

At the downstream end of the lateral is placed an overflow to take any excess flow. (It should however be noted that large secondary laterals feeding tetrary laterals would be fitted with constant D/S gates throughout like the "main canal" shown in figure 4, and would thus require no overflow; this will be explained in the next section on downstream control).

Suppose now that a farmer shuts his module. The level in the lateral tends to rise near his intake, but being controlled by a constant U/S level gate, is quickly reduced to its former value by a partial increase of gate opening. In consequence, more flow is passed downstream and in this way, all gates downstream open up slightly until the overflow is reached; the extra flow is thereupon run into a drain.

Usually of course the battery of main intake modules is set to give the sum of discharges required by individual farmers. No complicated head measurements, etc., are required—only a simple series of module settings.

Automatic Irrigation with Downstream Control

This time, a constant D/S level gate is located U/S from each individual farmer's intake; once more the level in front of his module is maintained constant.

At the intake there is no battery of modules, but only a constant D/S level gate of large size, as before. There is no overflow at the end of the lateral as now the total flow delivered is determined by the demand and there is no waste. This can be seen as follows:

If a farmer shuts his module, the level in the lateral opposite his intake tends to rise. This is prevented by his D/S level gate, which closes in order to restore the original level. This gate is followed by all others upstream along the lateral, and the inflow into the lateral is thus finally made equal to the demand.

Relative Advantages of the Two Systems

The second system is more attractive from a theoretical standpoint, as the canal system has a reserve pondage capacity (see fig 7) which can be availed of when sudden demands for more discharge occur, and all waste of water is avoided. Unless, however, the canal banks are "stepped" at the site of each D/S gate, there is a waste of canal freeboard capacity (as seen in fig 7), which is avoided in the first U/S system. (It should be remarked, that, as the cost of gates is about one per cent of that of the canals any savings on the latter, however small, outweigh slight differences in the price of the gates).

This brief summary does not pretend to cover all Neyrpic developments in automatic irrigation and watersupply systems. Considering irrigation alone, many other devices such as:—

IV—The Neyrpic flow divisor, for the distribution of flow between two or more canals independently of downstrem levels (see fig. 8);

V—The Neyrpic partialized siphon, for drawing off excess flow in irrigation canals; and

VI—The new constant D/S level gate which is able to protect the canals against drying out, on the one hand, and against the possibility of flooding (due to an accident to the reservoir intake) on the other, by switching over to U/S working when certain limits of level are exceeded;

—can be no more than mentioned in passing in the present brief introduction to automatic methods of working.

Conclusion

The benefits of automatically controlled irrigation systems are manifold:

(a) Reduction of canal freeboards to a few centimeters;

(b) Constant individual discharges under all conditions;

(c) Reduction of supervisory staff to a strict minimum;

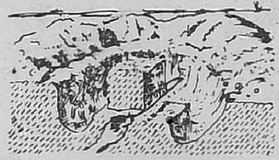
(d) Minimum waste of water.

The economies so effected will usually permit of the replacement of earth canals by lined ones —with consequent further improvements to the system.

—*With acknowledgments to "Indian Construction News" December, 1952.*

1. SMOOTH GROUND SURFACE AND MARK OUTLINE OF SAMPLE
2. CAREFULLY EXCAVATE TRENCH AROUND SAMPLE.

3. DEEPEN EXCAVATION AND TRIM SIDES OF SAMPLE TO DESIRED SIZE WITH KNIFE.



4. CUT SAMPLE FROM PARENT STRATUM, OR ENCASE SAMPLE IN BOX BEFORE CUTTING AS SHOWN IN C IF SAMPLE IS EASILY DISTURBED.

A

TO OBTAIN A HANDCUT SAMPLE FROM THE BOTTOM OF A TEST PIT OR A LEVEL SURFACE

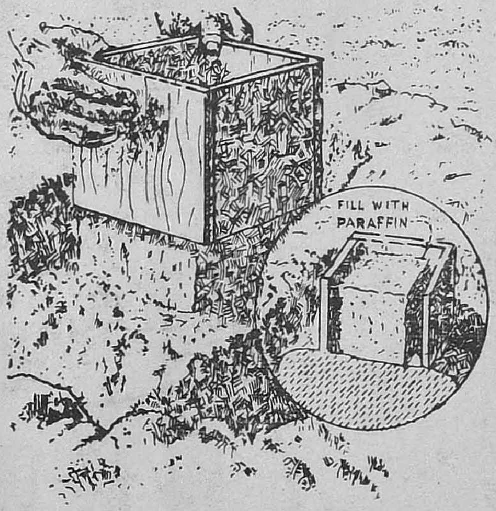
CAREFULLY SMOOTH FACE SURFACE AND MARK OUTLINE OF SAMPLE.

2. CAREFULLY EXCAVATE AROUND AND IN BACK OF SAMPLE. SHAPE SAMPLE ROUGHLY WITH KNIFE.

3. CUT OFF SAMPLE AND CAREFULLY REMOVE FROM HOLE, OR ENCASE SAMPLE IN BOX BEFORE CUTTING AS SHOWN IN C IF SAMPLE IS EASILY DISTURBED.

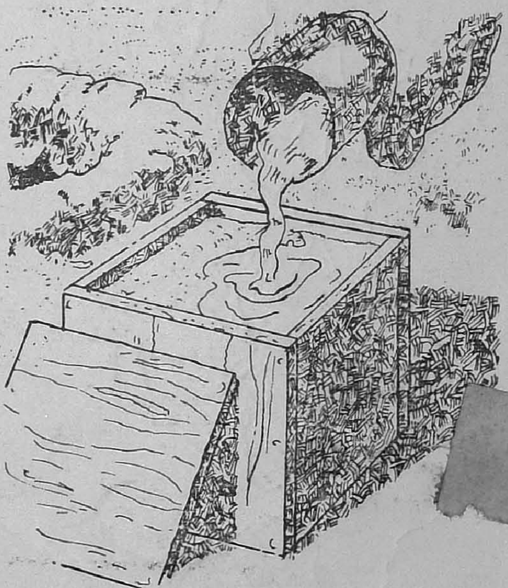
B

TO OBTAIN A SAMPLE FROM A CUT BANK OR SIDE OF A TEST PIT.



C

ENCASE EASILY DISTURBED SAMPLES IN BOX PRIOR TO CUTTING.

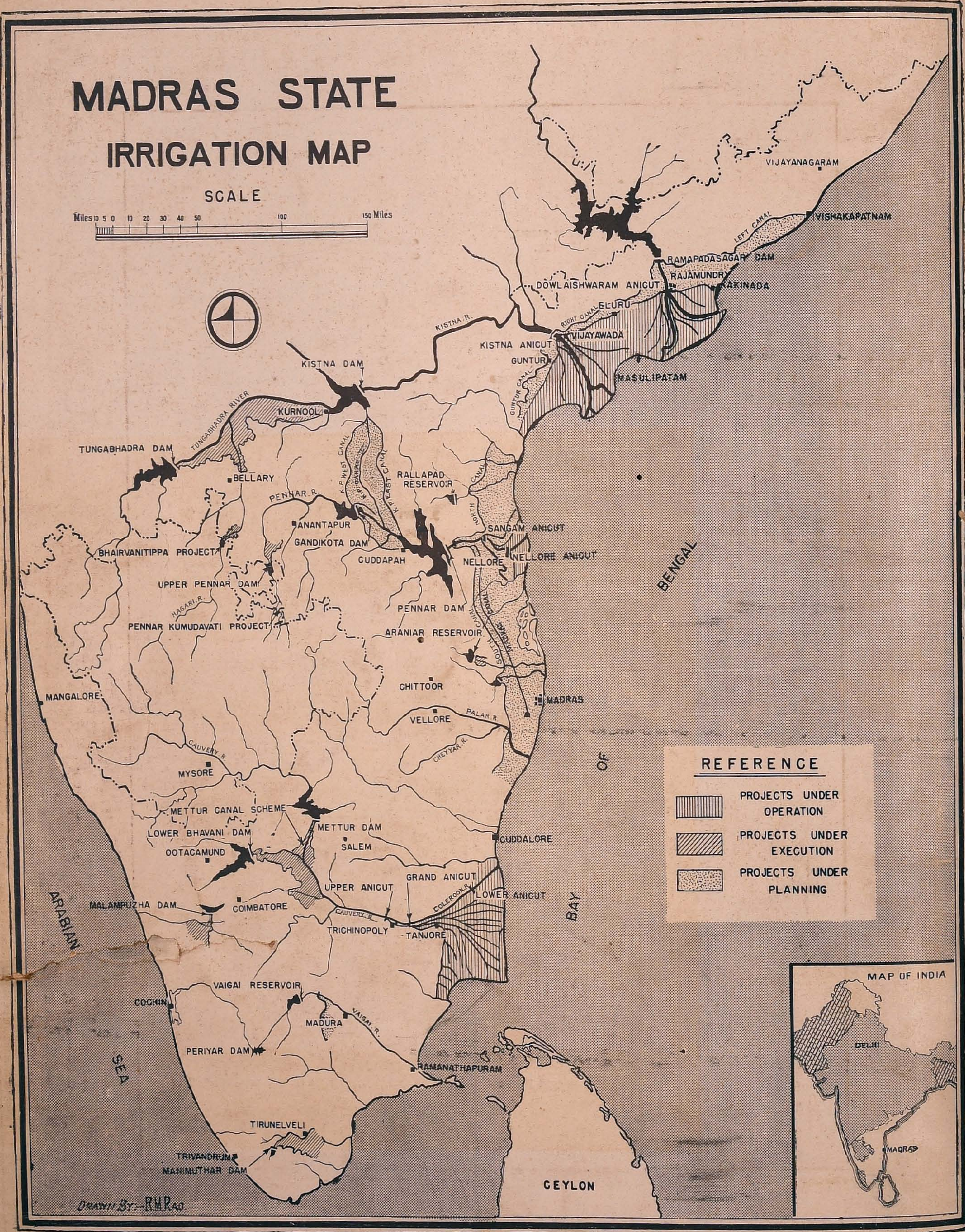


D

SEAL SAMPLE WITH PARAFFIN TO PREVENT MOISTURE LOSSES.

HAND-CUT BLOCK SAMPLES

TRACED : R.N.K.



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